University of Alberta

Performance of Children with Attention Deficit Hyperactivity Disorder-Combined subtype on the Stanford-Binet Intelligence Scale, Fifth Edition

By

Paula Corey Blashko

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Abstract

The psychopathology of Attention Deficit Hyperactivity Disorder (ADHD) consists of the behavioural symptoms of inattention, hyperactivity, and impulsiveness, is well recognized in children and adolescents, and is reported as one of the most frequently seen problems in child psychology and psychiatry. Although there has been concern about the utility of IQ tests in helping to diagnose ADHD, the ability of psychometric tests to provide information properties on a variety of constructs is thought to provide useful clinical information about the higher cortical functions in children with ADHD. The development and release of the of the Stanford-Binet Intelligence Scale, Fifth Edition (SB5) presents an opportunity to examine the nature of intellectual functioning, via examination of profile patterns, in special populations. This study compared the profile patterns of children with ADHD-Combined subtype (ADHD-C) and normal Controls, on the SB5. This study employed an ex post facto design, comparing the archival data of 29 participants with ADHD-C to 50 participants in the Control group. The Full Scale IQs for the ADHD-C and Control groups were analyzed and compared using the Analysis of Variance (ANOVA) procedure. The Verbal and Nonverbal IQs, and factor scores of the two groups were analyzed and compared using Multivariate Analysis of Variance (MANOVA). Further stepwise dicriminant function analysis was used to examine if group membership could be predicted based on the SB5 scores. The results of this study indicate that children with ADHD-C and children in the Control group do not differ significantly on the Full Scale IQ, Nonverbal IQ, or

Verbal IQ. When examining the five factor indexes it was observed that the two groups do differ significantly on the Working Memory factor. Further examination of Working Memory at the subtest level found that children with ADHD-C displayed significantly lower performance on the Nonverbal Working Memory subtest but not on the Verbal Working Memory subtest scores when compared to their Control group counterparts. A secondary analysis employing stepwise discriminant function analysis indicated that the two groups, in this study, could be differentiated from each other with 82.3% accuracy base on the subtests scores obtained on Working Memory.

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CHAPTER ONE

INTRODUCTION

Theoretical Framework and Problem Statement

In the last decade there has been an astonishing growth in the number of school-aged children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) (Purdie, Hattie, & Carroll, 2002). ADHD is expressed by a complex constellation of primarily behavioural symptoms that affect academic, cognitive, and social development of 3-5% of the school-aged population (Barkley, 1998) and up to 50% of child psychiatry clinical populations (Cantwell, 1996; Guevara et al., 2001). It is a chronic disorder that may manifest different characteristics in different developmental stages from preschool to adulthood. The impact of ADHD on normal development and functioning of the individual over the course of their life is considerable. Untreated, ADHD predisposes a child to psychiatric and social pathology (Babinski, Hartsough, & Lambert, 1999). Children with ADHD are more likely to experience academic failure, delinquency, strained peer and family relations, and poor self-esteem (Biederman, Faraone, & Milberger, 1996).

One important feature of this disorder is associated with the long-term consequences on personal and social development (Barkley, Murphy, & Kwasnik, 1996; Wilson & Marcotte, 1996). Approximately 70% of children diagnosed with ADHD in childhood continue to have cognitive and attentional problems in adolescence and adulthood (Wilson & Marcotte, 1996). Children

with ADHD are more likely to experience academic failure, delinquency, strained peer and family relations, and poor self-esteem when compared to children without ADHD (Barkley, 1990; Barkley, 1997; Biederman, Faraone, & Milberger, 1996). Children with ADHD are more likely to manifest antisocial behaviour, drug and alcohol abuse, have difficulty working independently, and often do not attain their full economic and occupational potential when compared to children without ADHD (Barkley, 1997). As adults, they are at higher risk for development of psychological disorders such as anxiety, oppositional and conduct disorders, and antisocial personality disorders (Barkley et al., 1996). There is an increased risk of developing drug or alcohol dependence (Biederman et al., 1995). The long-term prognosis for individuals with ADHD is better with early identification and intervention (Barkley, 1997a).

Despite the fact that the diagnostic criteria associated with ADHD are primarily behavioural, cognitive deficits such as impairments in attention, response inhibition, and working memory have been hypothesized to also be core features of the disorder (Barkley, DuPaul, & McMurray, 1990). While the current research on the aetiological basis of the ADHD is still growing and diverse, there is empirical support for the idea that ADHD is both a cognitive disorder and a behavioural disorder (Barkley, Grodzinsky, & DuPaul, 1992; Kronenberger & Meyer, 1996). Barkley (1997) has suggested that some children with ADHD have cognitive deficits of sustained attention and inhibitory control related to frontal lobe dysfunction in the brain and this theory

is supported by neuropsychological testing data (Barkley, Grodzinsky, & DuPaul, 1992). Barkley (1997) hypothesizes that ADHD is reflective of deficiencies in the area of response inhibition, which impacts executive functioning in four specific areas, including self-regulation of affect, internalized speech, working memory, and reconstitution of verbal fluency. Barkley reported impairment on tests that measure these executive functions. In theory, these hypothesized cognitive deficits support the diagnostic use of the Wechsler scales because of these tests purported ability to measure such cognitive skills as memory, attention, and visual organization (Sattler, 1992). The theory that working memory deficits are present in children with ADHD is supported by data that has been gathered based on testing of Baddeley's Working Memory Model (1986) in children with ADHD.

Given that the primary indicators of attention deficits include increased impulsiveness, hyperactivity, difficulties with arousal modulation, and inability to delay gratification, it may be expected that children with ADHD could manifest some differences or idiosyncratic patterns in intelligence test scores relative to other clinical or nonclinical groups of children (Saklofske, Schwean, Yackulic, & Quinn, 1994). Practitioners have raised questions about general and subtest performance of ADHD children on standardized intelligence measures.

While substantial amounts of research have been completed regarding the profile patterns of various groups (e.g. Learning Disabled, Gifted, and

Mentally Retarded children) utilizing the WISC-III, there is a paucity of literature and evidence in terms of utilizing the Stanford-Binet to examine the profiles of these types of special populations. Since the development and extensive use of test batteries to evaluate intelligence, such as the Wechsler and Stanford-Binet Intelligence Scales, there has been a long-standing debate regarding whether there is sufficient empirical foundation for the practice of employing profile analysis to make diagnostic and treatment planning decisions for children that have special needs (Saklofske et al., 1994). The test publishers (Wechsler, 1991, 2003; Roid, 2003c) argue that their intelligence measures have the capacity to differentiate between children with ADHD and those without ADHD. However, research data using subtest profiles, factor scores, and overall IQ, have been largely inconclusive or conflicting. Despite the inconsistencies in the research data, profile analysis is still utilized by a large proportion of school psychologists when making diagnostic decisions (Pfieffer et al., 2000).

The Stanford-Binet Intelligence Scale-Fifth Edition (SB5) currently represents the most recent edition of an assessment tool that has a long history of clinical utility. The SB5 is an individually administered assessment of global intelligence and cognitive abilities that may be used for individuals between the ages of 2 and 85. The complete scale known as the Full Scale IQ (FSIQ) consists of 10 subtests, which, in a number of configurations, provide other scales, namely the Nonverbal IQ (NVIQ), based on five nonverbal subtests, and the Verbal IQ (VIQ), based on five verbal subtests. The Nonverbal and Verbal

IQs are each based on five cognitive factors, also referred to as indexes, evaluated by the SB5: Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory (Roid & Barrum, 2004).

The factor indexes are based on the research of Cattell (1971), Horn (1994), and Carroll (1993). The research of Cattell, Horn, and Carroll has been named the CHC theory (McGrew & Woodcock, 2001) or the Gf-Gc theory by Horn and Noll (1997). The SB5 factors are supported by theory as having evidence of construct validity. By using the SB5 the pattern of strengths and weaknesses generated in an individual's profile should, in theory, allow the assessor to understand the nature of that child's cognitive abilities in order to make decisions and design interventions to help remediate weaknesses and magnify strengths (Roid, 2003c).

Rationale for the Study

Intelligence scales have enjoyed widespread use and popularity for the last several decades (Kamphaus, 1993). A primary function of these measures has been diagnostic in nature, centered on distinguishing children with exceptionalities from others in the general population (Roid, 2003c; Sattler, 1992; Wechsler, 1991b). Despite the esteem of intelligence tests, considerable debate has occurred over the appropriateness of the measures for this function, such as in the diagnosis of ADHD (Schwean & Saklofske, 1998).

The high prevalence rates and long-term impact of ADHD is of great concern to psychologists, educators, children, and the families of those affected directly or peripherally. Accurate and reliable diagnosis is imperative if the best outcomes are to be achieved (Daley & Nagle, 1996). A significant number of referrals to psychologists pertain to the determination of whether or not a child has ADHD. Part of the assessment process requires the administration of a cognitive measure with the intent of evaluating a child's strengths and weaknesses. In addition, there is also interest in establishing if these cognitive patterns connect to the theoretical constructs proposed to be identified with a particular disorder. For example, deficits in working memory are thought to be associated with ADHD (Barkley, 1997) and performance on a measure that evaluates this construct lends support to the utility of that instrument. Pfeiffer et al. (2000) reported that in a survey of 354 nationally certified psychologists, 89% of the respondents regularly use profile analysis to make diagnostic decisions and suggest educational placements. However, many researchers dispute the utility of profile analysis (Stanton & Reynolds, 2000).

A variety of strategies can be employed when interpreting tests. Some of the literature on intelligence supports norm-referenced and profile analysis approaches (Kaufman & Litchenberger, 1999; Sattler, 2001). In profile analysis, the examinee's scores are compared with one another, called ipsative or intra-individual comparison (Kaufman, 1994). This approach depends on the examination of statistical differences among scores, their relative magnitudes,

and their patterns. The purpose of the profile analysis approach is to identify clinical types and diagnostic patterns, or to establish relative strengths and weaknesses of the cognitive abilities proposed to be measured by the test (Roid, 2003c).

Despite the long history of the Stanford-Binet Intelligence tests, most clinical research on profile analysis has been done with the Wechsler scales (Bray, Kehle, & Hintze, 1998) as noted previously. To date, however, several studies investigating the relationship between ADHD and the WISC-III test performance have been inconsistent in their design and conclusions (Prifitera & Dersh, 1993; Saklofske & Schwean, 1993, Schwean & Saklofske, 1998). The new edition of the Stanford-Binet (Stanford-Binet: Fifth Edition [SB5]), represents a major revision from both a theoretical and operational standpoint from prior editions and other intelligence measures such as the Wechsler scales. There is, therefore, a new impetus to examine the clinical utility of this tool from a perspective of profile analysis for special populations such as for children with Attention Deficit Hyperactive Disorders.

Looking at the profiles rather than just the Full Scale IQ (FSIQ) is particularly important for the ADHD diagnostic category. The Full Scale IQ, as measured by intelligence tests, is the most reliable measure of *g* (general intelligence), existing among the scores of an intelligence battery. The Full Scale IQ uses all facets of the test and is considered to be the most effective predictor of long-term educational attainment as measured by school-based

achievement (Kaufman, 1990). However, the use of the Full Scale IQ in assessment and treatment of many conditions is not helpful (Carroll, 1993; Gustafson, 1984). Research data reveal that the Full Scale IQs of ADHD children are normally distributed (Kaplan, Crawford, Dewey, & Fisher, 2000) when comorbid conditions such as Learning Disabilities do not confound the results. It is therefore necessary to look beyond the Full Scale IQ and look at Verbal and Nonverbal IQ differences, factor scores, and intrasubtest scatter to see if we can further delineate the features of the individuals in these groups according to their cognitive strengths and weaknesses.

Purpose of the Study and Research Questions

The purpose of this study is to explore the scores and patterns of scores obtained on the Stanford-Binet Intelligence Scale: Fifth Edition by school-aged children with Attention Deficit Hyperactive Disorder (Combined Type) and children without ADHD, in order to identify if there are consistent patterns in subtest or factor scores that can effectively discriminate between these two groups of children. It is postulated that children with ADHD will show significant differences on tasks that demand increased degrees of sustained attention, working memory, mental computation, problem solving, hindsight, forethought, and application of planning and organizational skills (Barkley, 1996, 1997a, 1997b; Hulme & Mackenzie, 1992; Pennington & Ozonoff, 1996; Siedman, Biederman, Faraone, Weber, & Ouellette, 1997).

This study is exploratory in nature and is intended to provide more information about the SB5 Full Scale IQ, the five factors, and subtest patterns in a sample of children with ADHD-Combined subtype relative to children without ADHD (or any other disabling conditions). This research may be considered an initial step in determining whether there are differences on the Fluid, Knowledge, Quantitative, Visual-Spatial Processing, and Working Memory factors in children with ADHD-Combined[1] subtype and those in the non-ADHD group. This research is also intended to improve the clinician's understanding of the cognitive capacities of children with ADHD.

The goal of profile analysis is to generate hypotheses about the child's cognitive abilities. When the hypotheses appears to be reasonable (when used in conjunction with other standardized test data and interview data), they can be used to (a) clarify the functional nature of the child's learning problems, (b) arrive at treatment recommendations, (c) develop educational programs, and (d) recommend a vocational placement.

The specific research questions related to evaluation of profile differences in children with ADHD and the Control group using the SB5 follow. The questions will be restated as hypotheses in Chapter 3.

Question 1) Are there significant differences between the Full Scale IQs of children with ADHD and the non-ADHD group?

Question 2): Are there significant differences between the Verbal and Nonverbal IQ scores between the ADHD and non-ADHD groups?

Question 3): Are there significant differences between the Factor index scores between the ADHD and non-ADHD groups?

Question 4): Are there significant differences between the Verbal and Nonverbal subtest scores between the ADHD and non-ADHD groups?

Proposed Significance

With a better understanding of the cognitive structures and their varying levels in children with ADHD, more time could be used to provide direct and proactive services within the home and school settings. This research also endeavors to help psychologists and educators better understand the cognitive capacities of ADHD children and help in the design of remediation and intervention strategies in order to ameliorate some of the issues that interfere with an individual's functioning. The significance, overall goals, and scientific contributions of this study are as follows:

1. This study attempts to contribute to our understanding of the performance of children with ADHD using the Stanford-Binet: Fifth Edition.
2. This work also aims to help researchers verify the usefulness of the SB5 profiles as potential screening mechanisms for ADHD, and assist clinicians in the process of establishing if more extensive testing is required.

Definition

Attention Deficit Hyperactivity Disorder (ADHD): The DSM-IV most closely approximates the factor-analytic findings (Barkley, 1998) by listing symptoms into two core dimensions (inattention and hyperactivity-impulsivity) and allow for three subtypes to be identified: ADHD-primarily Hyperactive, ADHD-primarily Inattentive, and ADHD-combined subtype (APA, 1994). An additional ADHD Not Otherwise Specified (ADHD NOS) category can be used for children who have problems with attention, hyperactivity, or impulsivity but fail to meet the complete ADHD criteria. There are nine symptoms within each dimension in DSM-IV. The inattention group of symptoms consists of behaviors that include lack of attention to details, difficulty sustaining attention, failure to listen, organizational problems, distractibility, failure to complete activities, and forgetfulness. The hyperactivity-impulsivity cluster consists of excessive behavior, squirming, difficulty remaining seated, inappropriate noise/vocalization, and difficulty waiting for one's turn. The DSM-IV (1994) maintains the requirement of an early age of onset (before 7 years of age), present for 6 months or longer (to indicate chronicity), and present in two or more settings (to indicate pervasiveness of symptoms) (APA, 1994). The symptoms must be more frequent and severe than those of children of comparable developmental level and must cause significant functional impairments.

CHAPTER TWO

Literature Review

The information presented in this literature review provides the background information and context for this study. The organization of the information falls into five broad sections, with several subdivisions within each area. The first section (Section I) examines the nature of the Attention Deficit Hyperactivity Disorder (ADHD) and the impact it has on the individuals that live with this problem. Section II explores how intelligence is conceptualized and discusses contemporary theories relevant to the Stanford Binet. The development of standardized intelligence tests such as the Stanford-Binet Intelligence Scale, Fifth Edition (SB5) is discussed in Section III. This section includes specific details about the nature of this latest version of the Binet scale, including its psychometric properties. The fourth section (Section IV) evaluates the current research on the cognitive profiles of children with ADHD. Finally, Section V presents the hypotheses generated, based on the available literature, for the purpose of the present study.

Section I

Attention Deficit Hyperactivity Disorder: Its Nature and Consequences

The symptoms associated with Attention Deficit Hyperactivity Disorder (ADHD) were first identified by the physician George Still in 1902. The impact of ADHD in children is considerable as it interferes with normal development

and functioning. Untreated ADHD predisposes a child to psychiatric and social pathology in later life. The purpose of this section of the literature review is to collate and summarize some of the current literature that is relevant to the proposed study. This part of the chapter will be divided into several subsections including 1) the fundamental aspects of ADHD with descriptions of the disorder (epidemiology, core clinical features, differential diagnosis and assessment, comorbidity, and developmental changes in expression; 2) putative etiological bases that have been described in the literature (genetics and hereditary factors, neurochemical, neuroanatomical, neurophysiological, and neuropsychological factors); and 3) a description of the role of attention (including theoretical models applicable to ADHD) and the cognitive features of ADHD, as well as the 4) the impact of this condition on learning.

1. The Fundamental Aspects of ADHD

A. Epidemiology

Estimates of ADHD range from 3.5 million to 17 million children and adults in North America (Cantwell, 1996). The figure usually given for prevalence is 3 to 5 percent of school-age children in the general population according to most cross-national epidemiologic studies utilizing the standardized diagnostic criteria of the DSM-IV (American Psychiatric Association [APA], 1994; Robison, Sclar, Skaer, & Galin, 1999). This figure does not take into account preschool, adolescent, and adult populations. Robison et al. (1999)

found that in the past decade there have been an increasing number of diagnoses made with 947, 208 children diagnosed with ADHD during office-based visits in 1990 and 2, 357, 833 diagnoses made in 1995. Prevalence rates vary depending upon the population sampled, the diagnostic criteria utilized, and the diagnostic instruments used (Goldman, Genel, & Bezman, 1998). Searight and McLaren (1998) suggest several potential reasons for the variability in prevalence rates, including changes in diagnostic criteria and overlap between ADHD and other externalizing disorders.

Research data consistently documents a preponderance of boys over girls receiving the diagnosis of ADHD in both clinical and epidemiological samples (Cantwell, 1996; Weyandt, 2001). The rate is 9 to 1 in clinical samples and 4 to 1 in epidemiological samples (Cains, 2000). Several authors have commented that this may be indicative of a selective referral bias since girls may have primarily inattentive and cognitive problems and less of the aggressive/impulsive conduct symptomatology that leads to earlier referral in males (Baumgaertel et al., 1995, Cantwell, 1994b, Wolraich et al., 1996). Gaub and Carlson (1997) found that girls with ADHD showed lower levels of hyperactivity, fewer conduct disorder diagnoses, and lower rates of other externalizing behaviour but greater intellectual impairment.

B. Core Clinical Criteria

Although DSM-III (1980), DSM-IIIR (1987), and DSM-IV (1994) differ on core symptoms of ADHD and their arrangement, the criteria are quite

consistent. There is general agreement that the core constellation of symptoms consist of an inattention domain and a hyperactivity/impulsivity domain.

The DSM-IV most closely approximates the factor-analytic findings by listing symptoms into two core dimensions of inattention and hyperactivity-impulsivity (Barkley, 1997). Three subtypes are identified: ADHD-Primarily Hyperactive subtype, ADHD- Primarily Inattentive subtype, and ADHD-Combined subtype (APA, 1994; Barkley 1998). An additional diagnostic category, ADHD Not Otherwise Specified (ADHD NOS), may be used for children who have problems with attention, hyperactivity, or impulsivity but fail to meet the complete ADHD criteria. There are several symptoms within each dimension in the DSM-IV. The inattention group of symptoms consists of behaviours that include lack of attention to details, difficulty sustaining attention, failure to listen, organizational problems, distractibility, failure to complete activities, and forgetfulness. The hyperactivity-impulsivity cluster consists of excessive behaviour, squirming, difficulty remaining seated, inappropriate noise/vocalization, and difficulty waiting for one's turn.

The DSM-IV (1994) maintains the requirement of an early age of onset (before 7 years of age), duration of 6 months or longer (to indicate chronicity), and presence of behavioural indicators in two or more settings (to indicate pervasiveness of symptoms) (APA, 1994). The age of the child is critical as moderate levels of diffuse activity and short attention span are not uncommon in very young children (Barkley, 1990). Attention, concentration, and purposeful,

controlled activity increase with age. Nevertheless, half of ADHD cases have an onset prior to age 4 (APA, 1994). The disorder may not be apparent until the child begins school. The school environment can magnify ADHD-type problems because school activity is more structured and peer comparisons are more obvious (Barkley, 1998). When the diagnosis is made after seven years of age, retrospective accounts showing onset of the behaviours prior to age 7 are required (Biederman, 1991).

The symptoms must be more frequent and severe than those of children of comparable developmental level and must cause significant functional impairments. Symptoms may vary in frequency, in their pervasiveness across settings, and in the degree of functional impairment in each area across children (Cantwell, 1996). Also, within the same child, some settings may enhance or decrease symptom manifestation.

C. Differential Diagnosis and Assessment

The diagnosis of ADHD is a clinical diagnosis. It is made on the basis of a clinical picture that begins early in life, is persistent over time, pervasive across different settings, and causes functional impairment at home, school, and/or in leisure settings (APA, 2000). There is no laboratory test or set of tests that can be currently used to ensure a definitive diagnosis of ADHD (Arnold & Jensen, 1995; Barkley, 1990). The clinician must make use of a number of diagnostic tools including interviews with the parents, child, or teachers,

observations, standardized questionnaires, behavioural and neurological examinations, and cognitive testing. Symptoms are considered to be present and meaningful only if they are in excess of what would be expected in a child of the same age and cognitive level (APA, 2000). Diagnosing a child with ADHD must be done with great care as the presenting problems are similar to (and overlap with) many other childhood disorders such as learning disabilities, depression, or anxiety (Kaplan, Saddock, & Grebb, 1994). The differential diagnosis must rule out the presence of other psychiatric disorders, developmental disorders, and medical and neurological disorders which may be comorbid or mimic an ADHD syndrome (Cantwell, 1996).

D. Comorbidity

ADHD is associated with a plethora of medical, behavioural, cognitive, and academic disorders. Children with ADHD frequently do poorly in school; they are more likely to have physical problems than are other children; tend to have increased difficulties with peer acceptance; and are more likely to be anxious and depressed (Barkley, 1991, 1998; Biederman, 1991). Comorbidity is a major problem in children, adolescents, and adults with ADHD. Up to two thirds of elementary school-age children that are diagnosed with ADHD have at least one other diagnosable psychiatric disorder (Nottelman & Jensen, 1995).

The most common features associated with ADHD are those of Oppositional-Defiant Disorder, and Conduct Disorder (Weyandt, 2001). Other major comorbid conditions frequently found to co-exist with ADHD include:

language and communication disorders, learning disorders, anxiety disorders, mood disorders, and Tourette's syndrome or chronic tics (Cantwell, 1994; Clark, Barry, McCarthy, Selikowtz, 2002; Conner et al., 2002; Kadesjo & Gillberg, 2001).

The presence of comorbid disorders may require more intensive intervention and may signal increased risk for negative long-term outcomes (Biederman, 1991; Barkley, 1990). Cantwell (1996) also describes impaired social skills which, while not a DSM condition, is a common problem in many children, adolescents, and adults with ADHD. Comorbidity complicates the diagnostic process, impacts the natural history and prognosis, and alters the management of the individual with ADHD (Cantwell, 1996). Assessment and treatment of the comorbid condition is often as important as assessing and treating the ADHD symptomatology. The complexity that comorbid conditions contribute to the history, etiological basis, treatment strategies, response, and outcomes of treatment are considerable.

E. Psychopathology: Developmental Features

The core symptoms of ADHD may change over time. Most data is gathered from studies of elementary school aged boys. There are fewer studies of younger children, adolescents, and adults. The DSM-IV (1994) is often criticized because of the developmental inappropriateness of some of the items across life span (Hart, Lahey, Loeber, Applegate, & Frick, 1995). This

subsection will describe some of the changes in expression of ADHD symptomatology over time.

In the preschool age range, the most difficult differential diagnostic problem is the normally active but exuberant preschool children. Many parents of normal children describe their children as inattentive and hyperactive. The preschool child with true ADHD, which persists over time, generally has additional symptoms such as excessive temper tantrums, argumentative behaviour, aggressive behaviour, fearless behaviour that may lead to frequent accidental injury, and noisy, boisterous behaviour (Cantwell, 1996). Noncompliance or oppositional behaviour is often a major problem. Sleep disturbances are also common (Campbell, 1990). In a follow-up study done by Campbell (1990) it was found that approximately one-half of preschool children with a diagnosis of hyperactivity had a clear diagnosis by the age of 9. The children with more severe symptoms in preschool were likely to have the most persistent ADHD over time.

The various DSM criteria have been based on the clinical picture in elementary school-age children. Cognitively effortful work is considered to be most difficult for these children (Bayliss & Roodenrys, 2000). Entering into the academic arena in the elementary school age range puts greater stress on the cognitive domain. In addition, their impulsivity, hyperactivity, and inattention often leads to difficulty in peer relationships, which first becomes manifest in the elementary school age range (Barkley, 1998). Children with ADHD may

also begin to develop comorbid symptomatology such as oppositional behaviour, anxiety, or depression upon entry into elementary school (Cantwell, 1996).

The clinical presentation of ADHD in adolescents has not been studied as systematically as it has been in younger children (Barkley, 1998). Barkley suggests that not only do the symptom manifestations change with age, but a lower number of symptoms should be considered as indicative of a diagnosis in the adolescent, and possibly, adult age range. Barkley (1990) has noted that there is an increasing recognition that ADHD persists into adolescence in at least 50% to 70% of cases (see also, MacLeod & Prior, 1996; Weiss & Hetchman, 1992). Inattention and cognitive problems may lead to poorly organized approaches to school and work, and poor follow-through on tasks (Pineda et al., 1999). Failing to complete academic work is a hallmark in the adolescent age range. Continuation of risky types of behaviors may also be manifest (Barkley et al., 1993; Incorvaia, Mark-Goldstein, & Tessmer, 1999; Weiss & Hechtman, 1994).

The study of adults with ADHD is a more recent phenomenon. A variety of different symptoms in adults have been described by Wender (1994), Barkley (1995), and Connors (1995). The presence of disorganization continues to have an impact both in and out of the workplace. Poor concentration may persist into adult life leading to frequent inappropriate shifting of activities, not finishing projects, and poor quality work. Procrastination and intermittent emotional

outbursts may be related to comorbid mood symptomatology or may be a special type of labile mood described by Wender (1994).

2. Putative Contributing Phenomena to the Expression of ADHD

This section begins with the most basic aspects of expression of ADHD beginning with heredity factors. It will then broach the increasingly complex systems of expression including neuroanatomy, neurochemistry within these structures, and neurophysiology. Neuropsychological models of ADHD will also be explored.

A. Genetic and Hereditary Factors

Genetic and hereditary factors have been implicated in the development of ADHD. ADHD is generally considered a biological disorder that can be further potentiated by social factors (Ballard et al., 1997). ADHD is believed to travel along biological family lines (compared to adoptive families). First degree relatives of children with ADHD show an increased incidence of ADHD, depression, alcoholism, conduct problems, and antisocial disorders (Barkley, 1991; Biederman, 1995; Nigg & Hinshaw, 1998).

It has been reported that between 20% and 32% of immediate family members of ADHD children show symptoms of ADHD (Barkley, 1991). Biederman (1995) reported that if one biological parent has ADHD then the likelihood that the child will have ADHD is 57%. These results suggest a genetic link to behavioural outcomes. However, the increased family incidence

of ADHD could also be a result of environmental factors that remain stable from generation to generation (William, Wright, & Partridge, 1999).

Molecular genetic evidence gathered supports an association between ADHD and the D4 dopamine receptor gene (DRD4) and the D1 Transporter gene (DAT1) (Swanson et al., 1998). The DAT1 and DRD4 genes are believed to be responsible for neurological inhibition. The DAT1 gene allele may be associated with increased reuptake of dopamine and the DRD4 gene allele may be associated with a subsensitive postsynaptic receptor (Sunohara, Roberts, & Malone, 2000). Castellanos and his colleagues (2001) and Sunohara et al. (2000) are careful to report that these are new findings requiring further analysis and replication before any conclusions can be made.

The role of the two receptor genes implicated in ADHD does not exclude other genes in the dopamine pathway and other genes related to different transmitters such as the noradrenergic, serotonergic or cholinergic pathways (Castellanos, 1998). These are areas that have not yet been explored. Faraone (1999) and Barr (2000) both note that the dopaminergic pathway is a good place to start looking for specific genes but because brain mechanisms are complicated, dopamine is unlikely to tell the full story. Additionally, many of these authors state that genetic susceptibility does not exclude other causal factors such as environmental factors, pre, peri, or postnatal damage (Castellanos et al., 2001).

B. Neuroanatomical Factors

Prefrontal neurological functions such as impairment in the individual's ability to maintain attention, self-regulate impulsivity, and delay gratification are associated with the diagnosis of ADHD (Ballard et al., 1997). The frontal cortical section of the brain is related to learning and thinking (Kaplan & Saddock, 1994). The layer underneath, the subcortex, represents a relay system that is involved in sending messages to the processing and memory regions of the brain (Bear, Conners, & Paradiso, 1996). The subcortical system includes the brain's reticular activating system, thalamus, hypothalamus and basal ganglia. Magnetic Resonance Imaging (MRI) research suggests that ADHD children have impaired functioning in the cortical and subcortical areas (Garber, Garber, & Spizman, 1990). Particularly, frontal lobe and prefrontal dysfunctions have been implicated (Hynd, Kytja, Voeller, Hern, & Marshall, 1993).

Studies examining neuroanatomical differences between children with ADHD and children without ADHD have found that the frontal lobe region and corpus callosum (bundle of nerves that connects the right and left hemispheres) are smaller in children with ADHD (Hynd, 1991). Hynd (1993) found additional brain differences such as asymmetry in the caudate nucleus of individuals with ADHD. Similar anatomical differences have been reported by other researchers (Filipek, 1999; Geid et al., 1994; Semrud-Clikeman et al., 2000; Tannock, 1998).

Overall brain size in individuals with ADHD has also been reported to differ from non-ADHD individuals. Castellanos and colleagues (1994) found that total brain volume was 5% smaller in boys with ADHD when compared to boys without ADHD. These findings are supportive of Hynd (1993). Berquin (1998) reported that the cerebellum was significantly smaller in individuals with ADHD compared to those without the disorder. Although these studies indicate that anatomical differences often exist in the brains of individuals with ADHD compared to controls without ADHD, it is understood that the source of these differences remains unclear and is not necessarily responsible for ADHD symptoms (Barkley, 1998).

Caution must be exercised when interpreting the results of these studies. The sample sizes are often small and generalizability is limited. This problem is further compounded by the general lack of specificity in describing each individual with ADHD including the severity of the disorder, subtype, or confounding comorbid conditions provided. ADHD is understood to be a disorder that is expressed heterogeneously, thus poor description of the participants in a given sample makes interpretation tenuous.

C. Neurochemical Factors

Neurotransmitters are chemicals that relay messages from one neuron to another (Ballard et al., 1997). Billions of neurons and supporting cells exist within the brain, each with a multitude of synaptic connections to other neurons. Communication between neurons by neurotransmitters is essential for thought

and behavior and represents a major area of research in ADHD (Frazier & Merrill, 1997). Given the extraordinary complexity of the brain, no single transmitter is likely to account for the variety of symptoms associated with ADHD. The most frequently studied neurotransmitters thought to be linked to ADHD are dopamine, norepinephrine, and serotonin (Walsh & Darby, 1999).

It has been theorized that ADHD is due, in large part, to a dysregulation of a class of neurotransmitters believed to be involved in attentional systems. Catecholamines (derived from the amino acid tyrosine) implicated in ADHD include epinephrine, norepinephrine, and dopamine (Pliszka, McCracken, & Mass, 1996; Ballard et al., 1997; Vaidya et al., 1998; Walsh & Darby, 1999). These neurotransmitters are known to play a critical role in arousal and attention in both humans and animals. Norepinephrine is believed to be involved in the regulation of attention and arousal, learning, memory, anxiety, pain, mood, and brain metabolism (Bear et al., 1996). Dopamine is thought to be involved in modulatory systems that manage motor control, reinforcement, and stimulation (Bear et al., 1996). These transmitters relay messages through neural circuits that control motivation and motor activity such as restlessness and responsivity (Hynd et al., 1993). Individuals who have sustained damage to their brains in regions that involve these chemical pathways are found to display symptoms analogous to ADHD (Konrad, Gauggel, & Schurek, 2003).

The medication used in the treatment of ADHD (Ritalin/methylphenidate) serves to increase the release of catecholamines and

enable the brain to inhibit unwanted behaviours and to increase attention (Hamilton & Timmons 1990; Frazier & Merrel, 1997). It has been suggested that stimulants help to regulate faulty catecholamine systems and increase the catecholamines in the brain (Ballard et al., 1997; Denney, 2001; Robison et al., 1999). The mechanism of action of these drugs includes: facilitating synaptic dopamine release from the presynaptic site; inhibiting catecholamine degradation by monoamine oxidase in the presynaptic cell; and inhibiting dopamine reuptake (Wilens and Biederman, 1992). Dextroamphetamine and methylphenidate differ with respect to mechanisms by which catecholamine facilitation is achieved. Dextroamphetamine releases cytoplasmic stores of dopamine via reversal of the dopamine reuptake pump (Masand & Tesar, 1996), whereas methylphenidate releases vesicular dopamine stores (Russell, deVilliers, Sagvoden, Sergeant, & Sadile, 1998). This evidence strongly implicates dopaminergic mechanisms as a potential locus for the therapeutic benefits of psychostimulants. These findings, however, are of only limited value in the absence of data definitively connecting them to neurobiological substrates mediating the expression of symptoms central to ADHD (Denny, 2001).

Halperin et al. (1997) focused on the neurotransmitter serotonin derived from the amino acid tryptophan. They found that aggressive boys with ADHD had lower serotonin function than boys without ADHD. However, lower amounts of serotonin are not unique to ADHD and have been associated with other disorders such as impulsive personality disorders, violent behavior, and

depression. Kaneko et al. (1993) found that children with ADHD had significantly lower amounts of plasma cortisol relative to children without the disorder. They suggested that this finding may help to explain the hyperactivity, restlessness (Kaneko et al., 1993), as well as aggression (Van Goozen et al., 1998; Van Goozen, 2000) associated with ADHD.

At this time, the neurochemical dysregulation theory remains inconclusive because of the low number of individuals that have been used in these studies and design flaws such as low numbers of individuals used and poor descriptions of the inclusionary and exclusionary criteria used for participant selection (Pliszka, McCracken, & Mass, 1996).

D. Neurophysiological Factors

In addition to brain imaging studies, researchers have explored whether individuals with ADHD have a nervous system that is under- or hyperaroused. Monitoring heart rate, galvanic skin responses, and electroencephalograms (EEGs) are the primary means of evaluating these hypotheses. Contrary to popular belief of hyperarousal, many studies suggest that the individual with ADHD is not hyperaroused but rather their nervous system appears to be in a state of low arousal (Monastra et al., 1999; Launcht & Schmidt, 1999). The findings of these types of studies are consistent with previous anatomical and neurochemical studies that implicate the frontal lobe region in the underlying pathophysiology of ADHD.

3. Cognitive Aspects of ADHD

A. Executive Functioning

Although the direct cause of ADHD is unknown, genetic, anatomical, neurochemical, and neuropsychological studies collectively support a psychophysiological basis for the disorder. Generating a complete neurobiological or neuropsychological model of ADHD has been a more complex issue. Integration of the findings has not, as of yet, produced a fully explanatory and cohesive model of ADHD. Several models have been proposed.

In recent years, neuropsychological investigations of ADHD have focused on executive function (EF) and the role of the frontal-striatal-cerebellar brain systems (Barkley, 2000; Castellanos, 1997; Pennington & Ozanoff, 1996). The construct of EF is important in children because it is considered central in successful acquisition and efficient use of academic skills (Denckla, 1996). Executive function (EF) is a term used to refer to self-regulatory behaviours necessary to select and sustain actions and guide behaviour within the context of goals or rules (Mahone et al., 2002). EF involves developing and implementing an approach to performing a task that is not habitually performed (Mahone et al., 2002). Initiation, planning, shifting of thought, attention, organization, inhibition of inappropriate thought or behaviour, and efficiently sustained and sequenced behaviour are crucial elements of the EF construct (Mahone et al., 2002). As such, EF is treated as a collection of constructs that are fundamental

resources separable from the specific cognitive domains in which they are assessed, for example, linguistic and visuospatial abilities (Mahone et al., 2002). Barkley (1997a) developed a model that de-emphasized attention but highlights a deficiency in inhibitory control as the core of ADHD. Other researchers suggest that inhibition acts in parallel with other intentional skills including response preparation and working memory (Pennigton, 1997).

A number of researchers have theorized that ADHD may be due to a dysfunction of the frontal lobes. Neuropsychological studies of adults who had frontal lobe damage and displayed executive function deficits provided the framework for this theory. Executive function deficits are associated with ADHD and include disturbances such as impaired attention, planning, self-regulation, and impulsivity (Bayliss & Roodenrys, 2000). Barkley (1997), Mahone et al. (2002), and Biederman (2004) have hypothesized that it is possible that children, adolescents, and adults with ADHD may perform poorly on tasks used to measure neurological problems associated with executive function deficits.

Mahone et al. (2002) did a study of the effects of IQ on executive function (using the WISC-III) after controlling for sex, age, presence of LD, and medication use. The results indicated that there was a significant relationship between the Full Scale IQ and the 4 of the 5 EF measure used in the study. A secondary analysis showed group differences on the EF measures at different IQ levels. Children without ADHD performed better than children with ADHD at

the average IQ level but there were no significant group differences between children with ADHD and controls at the high average or superior IQ levels. This data was consistent with Denckla and Reiss' (1997) hypotheses that children with high IQs and that have ADHD may have an "overgrowing" (i.e. the cortex maturing to dominate subcortical deficits). This may be the mechanism by which these children perform well on the EF measures, and possibly outgrow the primary functional deficits of their disorders (Denckla & Reiss, 1997). However, the authors concede that this needs to be corroborated with data from imaging studies.

The association between executive function deficits (EFDs) and functional outcomes were examined among children and adolescents with Attention Deficit Hyperactivity Disorder (Biederman et al., 2004). Participants included children and adolescents with and without ADHD as diagnosed by pediatric and psychiatric clinics. Executive Function Deficits were defined as impairments on at least 2 executive function measures. Significantly more children and adolescents with ADHD had EFDs than did control participants. ADHD with EFDs was associated with an increased risk for impaired functioning as noted by grade retention and a decrease in academic achievement.

The results of studies utilizing neuropsychological tasks with individuals with ADHD have been mixed. Several studies have found that individuals with ADHD do poorly on tasks that require planning, forethought, inhibition of impulsive responding, working memory, and self-regulation but the findings

have not been consistent (e.g. Reader, Harris, Schuerholz, & Denkla, 1994; Mariani & Barkley, 1997; Rice & Weyandt, 2000). It is possible that inconsistencies in results are due to problems comparing studies that vary across age, symptom severity, task types, and intelligence of participants. Another possibility is that some neuropsychological instruments used in research do not reliably or adequately evaluate executive functions (Bayliss & Roodenrys, 2000). Attempting to evaluate executive function deficits is problematic because "Executive Function" is a loose term and there is not yet a clear or concise definition that would allow us to examine this area in a consistent fashion. Variable terminology and alternative conceptualizations of executive functions by different researchers impedes our ability to interpret the growing body of literature on this topic.

Current literature suggests that attention is a component of the broader class of executive functions. Attention is not a unitary construct and there are several models proposed to outline major components of attention and their underlying neurological structures (Kerns & Mateer, 1996; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Posner & Peterson, 1990; Sturm, Willmes, Orgass, & Hatje, 1997). Regardless of which model is adopted, most include separable components of attention: such as the ability to sustain attention over time (vigilance); the ability to attend to stimuli selectively; the ability to alternate or switch attention between stimuli or tasks; and the ability to divide

attention so as to maintain more than one ongoing process (Kerns, Eso, & Thomson, 2002).

Sohlberg and Mateer (1989a) suggested that attention is hierarchical. Their model suggests that lower levels of attention include basic functions such as being able to focus attention (with no competing stimuli) and sustain attention over time. Higher levels of attention, such as the ability to alternate quickly between tasks or to divide attention to be able to do more than one task at a time, require that the lower levels of attention are intact. Higher order aspects of attention are hypothesized not only to be dependent on these underlying skills but also to involve the ability to disengage attention and to inhibit responding. Such aspects of attention are dependent on the frontal regions of the brain and begin to overlap with some of the abilities that have been termed executive functions.

Three models that attempt to discuss executive function deficits within ADHD paradigms will be examined.

A.1. Barkley's Model of ADHD

The Behavioural Disinhibition Model, first described by Barkley (1997), suggests a potential unifying theory of ADHD. Barkley's position is that ADHD is due, primarily, to a deficit in behavioural inhibition that is physiologically based in brain's prefrontal lobes. This results in executive function deficits in four areas: self-regulation, working memory, internalized

speech, and reconstitution (which involves behavioural analysis and synthesis) (Barkley, 1997a, 1997b).

Barkley argues that ADHD is primarily a disorder of behavioural disinhibition resulting in impaired self-regulation. Disinhibition is considered the core causal cognitive process on which a spectrum of executive functions depends. Self-regulation develops as a function of brain maturation and learning to control one's impulses. Deficits in this system lead to secondary impairments in executive function such as the inability to plan adequately, problem solve, guide one's behaviour through internal speech, as well as in the motor control that these executive abilities affords. These deficits in executive function can have severe negative effects on academic, social, and behavioural skills in those suffering with ADHD (Purdie, Hattie, & Carroll, 2002).

According to Barkley's theory, these particular executive function deficits (self-regulation, working memory, internalized speech, reconstitution) are specific to ADHD and are not characteristic of other behavioural disorders such as Oppositional Defiant Disorder (ODD), Conduct Disorder (CD), or specific Learning Disabilities. Preliminary support for this model was found by Klorman and colleagues (1999). They found that executive function deficits were characteristic of children and adolescents with ADHD but not of children with reading or oppositional defiant disorders.

Barkley's (1997) theory, however, suffers from a central conceptual problem. The model posits that working memory and other executive functions

are causally dependent on the ability to inhibit prepotent responses. However, upon closer examination, the model cannot account for the actual control of inhibition or lack thereof (Rapport, Kyong-Mee, Shore, & Isaacs, 2001). According to Denney and Rapport (2000), responses that are characterized as disinhibited by Barkley may be appropriate responses to environmental events. Inhibition does not precede but rather follows the registration of the environmental events, leading to the question of how sensory events lead to the action of stopping and attending.

Denney and Rapport (2000) suggests that it is difficult to imagine impaired inhibitory ability without first ascribing a causal or mediating role to working memory as a primary controlling influence on inhibition. They suggest that working memory may be a primary core feature of ADHD, while the myriad of behavioral and cognitive processes attributed to impulsivity are peripheral variables or causal byproducts of deficiencies in working memory processes. According to this view, disinhibition is more appropriately viewed as a product of working memory processes rather than a cause thereof. More studies will be needed to test Barkley's and other researchers' (e.g. Denney and Rapport, 2000) conceptualizations of ADHD.

B. The Role of Working Memory

There has been increasing evidence that working memory plays an important causal role in the deficits in behavioural inhibition associated with ADHD. Of related interest are questions of how differences in working memory ability are manifested in children with learning disorders as compared to children with ADHD.

The concept of working memory has replaced and updated the concept of short-term memory, which is viewed as an active part of the information-processing system. This view contrasts prior, traditional, conceptualizations of short-term memory as a passive storage buffer. Working memory represents a person's information-processing capacity. Daneman and Carpenter (1980) developed a model of an information-processing system which they credited to the work of Newell who used the term working memory in their model (Newell, 1973; Newell & Simon, 1972).

While the concepts of working memory and short-term memory are similar in that they refer to the temporary storage of incoming information, the more contemporary view of working memory suggests that short-term memory is passive and working memory is active. Short-term memory refers to the passive storage of information while that information becomes either encoded into long-term memory or is forgotten. Working memory, on the other hand, serves as more temporary storage and is where calculation and manipulation of information occurs. Additionally, Baddeley and Hitch (1974) suggested that this

component stores the products or outputs of such calculations, in addition to the original information.

B.1. Baddeley's Model of Working Memory.

Baddeley and Hitch (1974) initially described a model, which incorporates working memory to account for a variety of data concerning human short-term memory. This model proceeded beyond the traditional view of short-term memory as a storage area because it emphasized mental processing. This model was based on the concept that short-term memory is active and therefore contributes to the processing of information to be retained. The original working memory model, and its later versions, describe a system of interacting subsystems, one specialized for verbal information and one for nonverbal information, with a central executive (Baddeley & Hitch, 1994).

The two subsystems are the phonological loop where verbal information is stored and processed and the visuospatial sketchpad where visual and spatial material is stored and processed (Baddeley, 1999, 2002). Baddeley and Hitch (1974, 1994) hypothesized that the phonological loop and visuospatial sketchpad are slave systems which enable the central executive to offload some of its own capacity for performing more complex information processing tasks. The central executive has been suggested to house the control of attention and action, to regulate information flow through the working memory system, and to

operate the retrieval of information from long-term memory (Baddeley, 1999, 2002).

The phonological loop component of Baddeley's model is conceptualized as being responsible for storing and processing verbal information. It involves some process of rehearsal to maintain the memory trace and is substantially affected by phonological interference. The phonological loop consists of two subsystems: a phonological store and an articulatory control process. The phonological store is responsible for the verbally presented information, while the articulatory control process is responsible for subvocal rehearsal of information. Subvocalization is considered necessary for rehearsal of information so that it does not decay and when Baddeley refers to verbal working memory he is referring to the phonological loop.

Baddeley (1999, 2002) argues that the phonological loop is fundamental to language acquisition and that individuals with a disturbance to this system will potentially have problems with reading and spelling. Children with ADHD have also been found to have poorer performance on the Arithmetic verbal subtest (requires keeping math word problem in mind while simultaneously calculating the answer), Coding nonverbal subtest (placing a symbol with a corresponding number which is dependent on keeping the symbol in working memory), and Digit Span Backwards verbal subtest (holding numbers in working memory and manipulating the series) subtest of the Wechsler Intelligence Scales for Children, Third Edition (Barkley, 1997; Sattler, 1992).

The visuospatial sketchpad is assumed by Baddeley (1994) to be a system for maintaining and manipulating visual and spatial information. Several functions of the visuospatial sketchpad have been proposed, including the hypothesis that it is involved in the processing of visual information, in planning and other executive tasks, in keeping track of the changes in the visual perceptual world over time (Kahneman, Treisman, & Gibbs, 1992), and in maintaining orientation in space and directing spatial movement (Thompson, 1983). This subsystem is also referred to as nonverbal working memory.

Grodzinsky and Diamond (1992) found that children with ADHD have lower performance than controls on tasks that measure visuospatial planning and nonverbal working memory (e.g. Porteus Mazes and Rey-Osterrieth Complex Figure). Other studies found that children with ADHD exhibited impaired performance on tasks requiring planning, forethought, hindsight, spatial location, organization, and reproduction skills (Douglas & Benezera, 1990; Sadeh, Ariel, & Inbar, 1996; Siedman et al., 1995, 1997). Children with ADHD perform significantly lower on the Visual Memory Index of the WISC-III, which is comprised of three subtests measuring visual immediate/working memory (Mealer, Morgan, & Luscomb, 1996). However, children with ADHD did as well as children without ADHD on Vocabulary and Information subtests of the WISC-III, which require retrieval of information from long-term storage. Mealer et al. concluded that children with ADHD have problems with working memory, but not short or long-term memory. That is, once information moves

beyond the preliminary stages of processing and into short and long-term memory, children with ADHD retain and apply information as well as controls.

C. PASS Theory, EF, and Implications for ADHD.

Another model that accounts for attention within an executive function paradigm is the PASS theory of intelligence posited by Das, Naglieri, and Kirby (1994). The PASS theory accounts for different regions of the brain and its functions, allowing for a comprehensive evaluation of cognitive profiles (including executive function deficits) for the individuals assessed (Das, 2002). The PASS theory identifies Planning, Attention, Simultaneous, and Successive cognitive processes as the components of intellectual functioning. The theory of intelligence as a cognitive process is based on Luria's information processing model (Luria, 1966, 1973, 1980) and cognitive psychological studies (Broadbent, 1958; Hunt & Lansman, 1986; Simon, 1980). Das, Kirby, and Jarman (1979) created the Information-Integration model based on these studies and more recently this theory has further evolved into PASS model of intelligence (Naglieri & Das, 1988, 1990).

The PASS acronym of this new model of intelligence represents the Planning-Attention-Simultaneous, and Successive components of cognitive processes (Das, Naglieri, & Kirby, 1994) based on Luria's (1973) idea that human cognitive processing involves three functional systems of units that work together and whose activity is necessary for mental function. The first functional unit prepares the system

to receive information by maintaining a proper state of arousal or cortical tone that allows for the focus of attention. Arousal, within the first unit, provides the opportunity for the voluntary action of attention, a complex cognitive activity. Attentional processes demand the direction of cognitive activity to a particular stimulus and inhibition of competing stimuli. The second functional unit receives, processes, and stores information using simultaneous and successive processing. The third functional unit is associated with frontal and prefrontal lobe function. It is thought to program, regulate and direct mental activity, primarily through planning.

The three units are dynamic, forming an interrelated system that also retains distinct functions depending on the task at hand. Effective processing is accomplished through the integration of knowledge with planning, attention, simultaneous, and successive processes as demanded by the task presented (Das et al., 1994). The PASS processes are interactive and work in concert to provide specific functions to virtually all tasks enacted in daily life. It is recognized that all processes are not equally involved in all tasks. Das et al. (1994), during test development, attempted to identify tasks in which a particular process plays a dominant role. Isolation of a process as much as possible allows for the evaluation of strengths and weaknesses in this system.

Das et al. (1994) admit that in reality one process may be more related to some but not all other processes, such as the close relationship between planning and attention, initially described by Luria (1980) and further elaborated by Stuss and Benson (1986). These authors indicate that there are substantial neural connections

between the first and third functional units of the brain. Planning requires an adequate state of arousal so that attention can be focused. Conversely, appropriate levels of activation, attention, and arousal are required so that plans of action can be created and employed. Effective planning demands that arousal is appropriate while there is inhibition of inappropriate arousal levels. This selective inhibition or facilitation of arousal is dependent on the third functional unit.

Review of the autonomic changes that accompany attention indicate that the frontal lobes play an important role in attentional processes. According to Das and his colleagues (1994), the role of the frontal lobes in controlling attention and inhibiting impulsive responses is very important. The frontal lobes are involved in the enlistment of attentional resources in voluntary attention, goal-directed, planful behaviour, and selective attention. Failure of selectivity is seen in impulsive behaviour of hyperactive children.

The limbic system is implicated in controlling arousal and attention. It is suggested that the brain stem reticular formation and the limbic system regulate attention, motivation, and emotion. The hypothalamus also plays a central role in all of these processes, therefore, attention and arousal are interactional processes involving cortical and subcortical structures. This interaction is well observed in attention deficits. In attention deficits, all components of attention beginning with the orienting response are adversely affected. During the orienting response, when frontal lobes do not control the direction of attention, then any stimulus may evoke an unspecific orienting response and promote distractibility (Naaten, 1982; Pribram &

McGuiness, 1975). Das, Naglieri, and Kirby (1994) suggest that failure of frontal regions leads to nonselectivity of attention through improper interaction between the limbic and frontal regions.

In summary, attention is organized in the brain in both the top and bottom parts of the brain. The upper part of the brain (neocortex), thalamus, and brain stem are closely interconnected in regulation of attention. The neocortex is primarily in control of guiding complex attentional processes. In contrast, the reticular activating formation plays a major role in maintaining arousal. Voluntary aspects of attention that are important for problem solving or listening to instructions in a learning circumstances are possible only when the upper parts of the brain, specifically the frontal lobes, are engaged. The regulation of attention develops as the frontal lobes and the limbic system work cooperatively. Arousal may occur in response to physical needs and by emotions in the context of socio-cultural significance. Arousal can therefore be mediated by circumstances that are cognitively interpreted. Amplification or inhibition of arousal is determined by the frontal lobes (Das, Naglieri, & Kirby, 1994).

Despite our growing understanding of attentional processes, identifying the cognitive characteristics, which includes the attention component of the PASS model, of individuals with an attention deficit disorder has been a difficult task. Many forms of assessment have been utilized with variable degrees of success. Some research using peripheral distracters has not provided substantial evidence that hyperactive children are more distractible than non-hyperactive children; however, research using

tools that assess sustained attention, impulsivity, and planning have yielded evidence suggesting cognitive deficits in these areas (Whalen, 1983, Douglas, 1980). Das, Naglieri, and Kirby (1994) made a significant observation that clearly indicates the difficulty of evaluating attention, "Although many instruments have been used to measure sustained and selective attention (CPT, Stroop), impulsivity (Matching Familiar Figures Test), planning (Porteus Maze), inconsistent findings and lack of theoretical base from which to understand and interpret processes measured by the tests diminish their diagnostic value" (p. 151). Das and his colleagues suggest that different patterns of the PASS processes must be investigated among distinct groups of exceptionalities (such as ADHD) in order to further clarify the cognitive processing profiles of these individuals.

4. Learning in Children with ADHD

More information regarding ADHD in childhood is available than for any other developmental period. Long-term studies indicate that ADHD symptoms persist during the elementary school years and additional problems such as academic problems, poor social skills, and poor peer relationships, conduct problems, and aggressive behaviour emerge (Barkley, 1998; Weyandt, 2001). This section focuses on academic performance and learning problems in children with ADHD.

Academic performance and learning problems are likely the most common associated difficulties that children with ADHD experience (Cantwell

& Baker, 1991). During the elementary school years many children with ADHD are academic underachievers. Approximately 40% have coexisting learning disabilities (Rapport, Kyong-Mee, Shore, & Isaacs, 2001). Reading disability is the most commonly identified learning problem with these children (Mayes, Calhoun, & Crowell, 2000). In addition, mathematical achievement tends to be lower than that of non-ADHD peers (Zentall & Smith, 1993). Overall, there is agreement that having ADHD will increase the likelihood of having academic problems (Evans et al., 2001; Schacher et al., 2002; Pelham et al., 2002; Frankenberger & Cannon, 1998).

It is not uncommon for children in elementary school with ADHD to require a tutor and/or begin receiving special education. Children with ADHD often talk in excess and manifest problems with organization and expression of thoughts in a fluent fashion (Purvis & Tannock, 1997). These problems of expressive language are currently considered to be related to cognitive processes such as poor planning and organizational skills that are associated with executive functions (executive functions represent an aspect of cognitive processes), rather than to be an underlying speech or language disorder (Purvis & Tannock, 1997). These executive function deficits are proposed to impact academic function. Barkley (1998) and others (Bayliss & Roodenrys, 2000) suggest that children with ADHD may have delays in internalized speech. Internalized speech is considered to be essential for the individual to control and govern his or her own behaviour. This, in turn, affects academic performance.

Teachers often criticize the ADHD child's disorganization, distractibility, and restlessness, which ultimately affect the child's ability to function in the classroom (Conner et al., 2002). Teachers frequently comment on the inability of children with ADHD to follow through on assignments and carelessness in their schoolwork (Reiss, 2002). These issues have led some to question whether children with ADHD have lower intelligence and/or memory deficits. Research concerning these questions have rendered mixed results. Some studies have found that children with ADHD have fallen below average on intelligence tests (Faraone et al., 1993). Other studies have found their performance to be average or above average on standardized I.Q. tests (Webb & Latimer, 1993). As with non-ADHD children, intelligence is likely to vary substantially among individuals and group findings can be misleading. Therefore, sample selection must be rigorously controlled. Incorvaia, Mark-Goldstein, and Tessmer (1999) also offer alternative explanations for lower scores on standardized intelligence tests. They reported that the differences may be attributable to actual deficits in abilities, due to impaired test-taking performance, or a combination of both.

Studies have not generally found deficits in short and long-term memory in children with ADHD. However, many studies have identified problems with the working memory of these individuals (Barkley, 1997a; 1997b; Klingberg, Fossberg, & Westerberg, 2002). The more complex the task and the greater the

requisite for organization and remembering information, the more difficulty these children appear to have (Amin, Douglas, Mendelson, & Dufresne, 1993).

Section II

Theories of Intelligence and Intelligence Testing

Intelligence is one of the most frequently investigated topics in psychology. Articles on the nature and methods of measuring intelligence are published in vast numbers each year. Despite this massive growth of the literature, the definition of intelligence remains mysterious, swathed in controversy. There is a fundamental paradox in modern testing, specifically that psychometricians are better at quantifying intelligence than conceptualizing it. There is much to be gained by evaluating the historical and contemporary efforts to elucidate the meaning of intelligence as intelligence tests are generally grounded in theory, empirical evidence, or both. Every test that exists includes some definition of intelligence. In order to comprehend contemporary intelligence testing it is necessary to assimilate particular definitions and theories. The goal of this section is to investigate the various meanings given to the term "intelligence" and to discuss how definitions and theories have impacted the structure and content of intelligence tests.

Sternberg (1986) makes a division between operational and real definitions that is important to consider in this context of defining intelligence. The operational definition defines a concept in terms of the way it is measured

(Boring, 1923). A real definition is one that attempts to make us understand the true nature of the concept being defined (Sternberg, 1986). Real definitions of intelligence are produced by the experts in the field. Intelligence has been given many definitions by prominent researchers in the field. Many definitions of intelligence appeared in an early symposium, "Intelligence and Its Measurement," published in the *Journal of Educational Psychology* (Thorndike, 1921). Other definitions are derived from a modern update of this early symposium, *What Is Intelligence?* edited by Sternberg and Detterman (1986).

What is intelligence?

Intelligence has been variously defined as:

1. A general ability which involves mainly the education of relations and correlates (Spearman, 1923).
2. The ability to judge well, to understand well, and to reason well (Binet & Simon, 1905).
3. The capacity to form concepts and grasp their significance (Terman, 1916).
4. The ability of the individual to adapt adequately to relatively new situations in life (Pintner, 1921).
5. The power of good responses from the view of truth or fact (Thorndike, 1921).

6. The capacity to inhibit instinctive adjustments, flexibly imagine different responses, and realize modified instinctive adjustments into overt behaviour (Thurstone, 1921).

7. The aggregate or global capacity of the individual to act purposefully, to think rationally, and deal effectively with the environment (Wechsler, 1939).

8. More recent definitions include: the entire repertoire of acquired skills, knowledge, learning sets, and generalization tendencies considered intellectual in nature that are available (Humphreys, 1971).

9. A generic term to indicate the superior forms of organization or equilibrium of cognitive structuring used for adaptation to the physical and social environment (Piaget, 1972).

10. The mental capacity to automatize information processing and to emit contextually appropriate behaviour in response to novelty, it also includes metacomponents, performance components, and knowledge-acquisition components (Sternberg, 1986).

11. Error free transmission of information through the cortex (Eysenck, 1986).

12. The ability or skill to solve problems or fashion products which are valued within one or more cultural settings (Gardner, 1986)

13. The ability to deal with information using four cognitive processes (Das, Naglieri, & Kirby, 1994).

Despite this diversity of responses to defining intelligence as a concept, experts tend to agree that intelligence is the capacity to learn from experience, and the capacity to adapt to one's environment (Gregory, 1992). It is useful to discuss theories of intelligence in order for us to understand how they have influenced the structure and content of intelligence tests. The following list represents a sampling of some of the theories that have impacted the development of the Stanford-Binet, Fifth Edition.

Theories of Intelligence

A. Spearman and the g Factor

Spearman (1904, 1923, 1927) proposed that intelligence consisted of two kinds of factors. He based his idea on the broad study of patterns of correlations between various tests of intellectual and sensory ability. He believed there was a single general factor, *g*, and numerous specific factors, s_1, s_2, s_3, etc. Spearman helped invent factor analysis to aid in the investigation of the nature of intelligence. This is a statistical technique to discriminate the number of separate underlying factors that need to exist in order to account for the observed correlations between a large number of tests.

According to Spearman (1923), an examinee's performance on any homogeneous test or subtest of intellectual ability was determined by *g*, the pervasive general factor, and *s*, a factor specific to that test or subtest. Spearman was primarily concerned with defining the nature of *g*, which he suggested was similar to a power or energy which serves in common the whole cortex. Spearman perceived the *s* factors to be localized in a specific physiological substrate in a group of neurons serving the particular mental operation demanded by a test or subtest (Spearman, 1923). Spearman reasoned that some tests were heavily loaded with the *g* factor while other tests were representative of a specific factor.

Spearman (1923) considered individual differences in *g* to be mainly reflected in the ability to use three principles of cognition: apprehension of experience, education of relations, and education of correlations. Although Spearman's physiological speculations have been largely discarded, the idea of a general factor persists (Jensen, 1979). The most difficult problem faced by Spearman's two-factor theory is the existence of group factors. As early as 1906 Spearman and others noted that relatively dissimilar tests could have correlations higher than the values predicted from their respective *g* loadings (Brody & Brody, 1976). These findings suggested that it was possible that a group of different measures could share a unitary ability other than *g*.

B. Vernon's Hierarchical Theory

Vernon developed a hierarchical theory of intelligence with general ability (*g*) at its apex (Vernon, 1965). He described two major factors at a lower level which were verbal-educational and spatial-mechanical. These factors were further subdivided into minor group factors (e.g. creative abilities, verbal fluency, numerical factors, spatial factors, psychomotor, and mechanical information factors. Each of these minor factors was, again, subdivided further into specific factors. Vernon believed that there must be a general factor (*g*) which represents a wide range of abilities and that it has to be considered when we endeavour to measure or understand intelligence.

C. R. Cattell and the Fluid/Crystallized Division of Intelligence

Cattell (1941, 1971) proposed a theory of the structure of intelligence that has been revised and expanded by Horn (1968, 1985). Cattell and Horn used factor analysis to study the structure of intelligence. Rather than identifying a single general factor they recognized two major factors that Cattell labelled fluid intelligence and crystallized intelligence. They described fluid intelligence as a largely nonverbal and relatively culture-reduced form of mental efficiency related to a person's inherent capacity to learn and solve problems. In contrast, crystallized intelligence is highly culturally dependent and represents what one has learned through the investment of fluid intelligence in cultural

contexts. Because of this relationship, there is a moderate correlation between the two types of intelligence (r=.5) (Horn, 1985).

In later versions of the fluid/crystallized theory of intelligence Cattell (1971) and Horn (1982, 1985) elaborated and proposed a four level hierarchical interlocking model of intelligence with fluid and crystallized components at the top. Horn (1985) rejected the concept of general intelligence. At the lowest level of his hierarchical model are visual and auditory sensory detection functions. The second level involves associational processes (both short and long term). The third level consists of perceptual organizational processes such as broad visualization, clerical speed, and broad auditory thinking. The highest level consists of fluid ability and crystallized ability. Horn's theory also is associated with developmental levels. Between infancy and adulthood, the sensory detection functions are elaborated; then associational processes develop; perceptual organizational functions develop subsequently; and then the capacity to comprehend relations and draw implications becomes most prominent in adolescence and adulthood (Sattler, 1992).

Horn (1998) further modified the theory by suggesting that there are 55 primary abilities and nine second stratum abilities. The second stratum abilities (Horn, 1987) include fluid ability (reason, sorting, classification); crystallized ability (knowledge emphasized by acculturation); visual processing, auditory processing, short-term memory, long-term memory, processing speed, decision speed, and quantitative knowledge. Horn (1985, 1998) has consistently argued

against the unitary theory of intelligence, believing that intellectual ability is made up of distinct functions (Horn, 1985).

D. Carroll's Theory of Cognitive Abilities: Three-Stratum Factor Analytic Theory

Much of the debate over intellectual assessment during the last 60 years has focused on the existence of an underlying global intelligence that influences an individual's performance across cognitive domains (Jensen, 1998). Based on Carroll's factor analytic studies (1993, 1997), there is evidence that a general factor of intelligence exists. Therefore, the trend towards an emphasis on multiple, more narrowly defined cognitive abilities has not resulted in the rejection of an underlying global aspect of intelligence. The factor analytic research has resulted in the identification of several broad domains of intelligence, underlying a broad, general factor (Horn & Noll, 1997), which is at the top of the hierarchical structure.

A three-stratum factor analytic theory of cognitive abilities was proposed by Carroll (1997c). This theory suggests that there are many distinct individual differences in cognitive ability and that the relationships among these differences can be organized into three levels or strata (Sattler, 2001). A hierarchical confirmatory analysis supplies evidence for the three-stratum theory (Bickley, Keith, & Wolf, 1995). The three levels of Carroll's theory are as follows: Stratum I (Narrow) consists of 65 narrow abilities comprising levels of

mastery in various cognitive areas (such as reading comprehension, numerical facility, reaction time); Stratum II (Broad) includes eight broad factors (fluid and crystallized intelligence, general memory and learning, broad visual perception, broad auditory perception, broad retrieval capacity, broad cognitive speediness, processing speed); and Stratum III (General) which represents a general factor, or *g*.

E. Cattell, Horn, & Carroll: CHC Model of Intelligence as the Foundation of the Stanford-Binet, 5th Edition

Cattell's (1993) research has resulted in a theory of intellectual ability that is highly regarded as a major empirically-based model of intelligence. The SB5 developers relied substantially on Carroll who integrated the work of Cattell (1943) and Horn (1965) into his own model. The result of the combination of these three theorists work is called the Cattell-Horn-Carroll (CHC) theory of intellectual abilities (Alfonso, Flanagan, & Radwan, 2005; Flanagan, 2000; Ford, 2002; Evans, Floyd, McGrew, & Leforgee, 2001). The CHC factors can be recognized in earlier editions of the Stanford-Binet scales (Roid, Woodcock, & McGrew, 1997). In order to maintain consistency between the most recent and prior editions of the Binet scale, five essential factors of the CHC theory were selected and retained for the SB5. The CHC theory recognizes ten factors existing under general intellectual ability (g) including five factors not utilized in the SB5: reading and writing ability, auditory

processing, long-term retrieval, processing speed, decision speed and reaction time; and five factors included in the SB5 known as fluid reasoning, quantitative reasoning, crystallized knowledge, short-term memory, and visual processing (adapted from pp. 8 in Roid, 2003c).

As noted above, the SB5 employs five factors from the CHC model. These five factors are Fluid Reasoning/Fluid Intelligence, Knowledge/Crystallized Knowledge, Quantitative reasoning/Quantitative Knowledge, Visual-Spatial Processing/Visual Processing, and Working Memory/Short-Term Memory. These factors are considered to have the highest g loadings in the CHC model which justifies their inclusion in the newest version of the Stanford-Binet (Roid, 2003c). The factors are also recognized as important amid the abilities evaluated by the earlier editions of the Stanford-Binet (Roid, Woodcock, & McGrew, 1997). The factor scores are based on extensive research in cognitive abilities. Five of the factors from the CHC model were excluded from the SB5 because the SB5 emphasizes reasoning, and they contributed to problems with adding to overall testing time and complexity in terms of test administration (Roid, 2003c). It is important to note that the memory factor was shifted from an emphasis on short-term memory only, as in the fourth edition of the Stanford-Binet to an emphasis on Working Memory. The important change in emphasis in the fifth edition is the duplication of all five factors in both the nonverbal and verbal domains (Roid & Barrum, 2004).

Section III

Binet Intelligence Testing

A. History

In the beginning of the twentieth century Alfred Binet, a psychologist, and Theodore Simon, a psychiatrist, published a "measuring scale of intelligence" that was developed for use with French schoolchildren (Binet & Simon, 1905). This measuring scale was developed with the intent of becoming a screening tool that would enable the French Minister of Public Instruction to identify mentally retarded children (Fancher, 1985). The scale was made up of a series of 30 brief cognitive tests, both verbal and nonverbal, arranged in order of difficulty. The tests included measures of language skills, reasoning, memory, digit span, and psychological judgments. The scale included tests developed by others as well as new ones developed by Binet and his colleagues.

The 1905 test was atheoretical and empirically derived. Validity was demonstrated by the increase of scores with age and by the scale's capacity to differentiate normal and cognitively impaired children. By 1908 a fundamental revision was made by Simon and Binet: grouping of the tests into age levels (Binet & Simon, 1908). This procedure came to be known as a year scale and each test was assigned to an age level in which most children performed it successfully. Administration to an individual child started with the tests at the individual's age level and continued to higher or lower age levels until finding the age level at which most items were failed. Intelligence was then enumerated

in terms of the intellectual level, later known as the mental age, defined as the highest level at which the child completed most items correctly. In 1911, a third revision of the Binet-Simon scales appeared: each age level had exactly five tests and the scale extended into the adult range.

The Binet-Simon scales have served as models of the form and source of content for later intelligence tests. The fundamental process of combining different mental tests to provide a composite score is the basis of intelligence scales (Sattler, 1988). Binet stated that "a particular test isolated from the rest is of little value" and that the important information contributed by intelligence scales was the subject's average performance over various tests (1911/1916, p. 329). The Binet-Simon scales also contributed items and tests that have been recycled in later intelligence scales, such as the Wechsler intelligence scales. In a very short time span the Binet-Simon scale became widely used in Europe and North America. In 1909 Goddard organized the translation of the Binet-Simon scale from French to English, with a number of revisions. This popularized intelligence testing in American establishments (Zenderland, 1998). In 1911, Goddard tested 2000 children for standardization purposes and soon after became one of the world's leading advocates of Binet's testing methods (Thorndike & Lohman, 1990).

The Binet-Simon scales helped solve the practical social problem of identifying children who needed special schooling. With this successful application of a mental test, psychologists began to comprehend that this

invention could have practical significance for many segments of society (Fancher, 1985). Intelligence testing was embraced in the United States as a reliable and objective response to perceived social problems such as the identification of mentally retarded immigrants and the quick, accurate classification of Army recruits (Gregory, 1992).

American psychologists, prior to the America's entrance into World War I, produced two major revisions of the Binet-Simon scale. Yerkes, Bridges, and Harwick (1915) made the first revision by restructuring the year scale of the Binet-Simon into a point scale, termed the Yerkes-Bridge Point Scale Examination. This was done by grouping items of similar content into a smaller number of subtests. Point-scale tests were administered beginning with the easiest item and advancing in order of difficulty until completing the test. The point-scale method pioneered by the Yerkes-Bridges scale became a model for tests that evolved into the Wechsler scales (Thorndike & Lohman, 1990).

Another revision, by Terman (1916), extended the age range into adulthood and replaced mental age with the intelligence quotient (IQ). Terman also supplemented the Binet-Simon tests with newer tests such as arithmetic reasoning and a form board. His version, the Stanford-Binet Scale, became the major measure in American intelligence testing. This new scale was suitable for use with the mentally retarded, children, and both normal and "superior" adults. This Stanford-Binet also had relatively clear and well organized instructions for

administration and scoring. However, there were still concerns that these instructions were somewhat subjective (Freeman, 1955).

A significant event in the spread of intelligence testing was the testing program carried out in the U.S.Army during the First World War. Yerkes, the president of the American Psychological Association at that time, gathered a committee of testing experts in order to design tests to establish which Army recruits were fit for military service. The committee included Doll, Goddard, Haines, Terman, Wells, Bingham, and Yerkes. A monograph on the history of wartime intelligence testing was edited by Yerkes (Yerkes, 1921). The monograph's technical errors and conclusions about racial and ethnic differences have been widely criticized (Gould, 1981). The main Army intelligence tests were group administered examinations. This required a transformation from the pre-war individual intelligence scales to the group-administered examinations. This was made possible by the method of multiple choice, largely credited to Otis (Yerkes, 1921). The Army group examinations were a key source of subtests and items used in the Wechsler-Bellevue scale (Frank, 1983).

Recruits that failed the group examinations were assessed with individual intelligence tests that included the Stanford-Binet, the Yerkes-Bridges point scale, and the new Army Performance scale. The Army Individual Examination, an individual intelligence test developed for the Army testing program by the committee, is believed to have had a strong influence on the

Wechsler scales. The Army Individual Examination was a point sale created for English-speaking recruits that consisted of 22, primarily verbal, tests taken from the Yerkes-Bridges point scale or adapted from the Group Examination (Boake, 2002). The Army Performance Scale was created for recruits who performed poorly on the Army Group Examinations or who were not proficient in English (Boake, 2002).

Wechsler, in 1917, enlisted in the Army and attended the School for Military Psychology in 1918 in order to become a psychological examiner. Wechsler, from his war experience of testing, later remarked that he felt that existing intelligence tests were inadequate because recruits who had functioned normally as civilians before induction failed the Army group examinations and obtained low mental age scores on the Stanford-Binet scale. This feature was attributed to the test's emphasis on verbal skills acquired through formal education (Wechsler, 1979).

The postwar decades represented an explosion in the development of intelligence tests and testing. New group intelligence tests were developed and application of intelligence testing further expanded. Development of performance tests increased, in all likelihood driven by concerns about the adequacy of the Stanford-Binet scale, despite its prominence through revisions in 1937 and 1960. Interestingly, many tests' value as measures of intelligence was demonstrated by making correlations with the Stanford-Binet scale (Kohs, 1923). Some postwar performance scales attempted to construct intelligence

scales only using nonverbal tests. These performance tests became popular with clinicians as a supplement to the Stanford-Binet scale (Report of Committee of Clinical Section of American Psychological Association, 1935).

B. Description of the Stanford-Binet Intelligence Scales

Terman and Merrill revised the Stanford-Binet scale in 1937 by extending the age range of the instrument from the ages 2 to 18 years and also by making an effort to improve standardization based on 3184 Caucasian American born subjects. The emphasis was on the evaluation of general intellectual ability rather than specific abilities. The age scale format and ratio IQ (IQ = mental age/chronological age X 100) was also retained. In addition, two forms (L and M) were developed. Overall, the 1937 revision was regarded as a milestone in the progress of testing intelligence in individuals (Sattler, 1988). Factor analytic studies revealed that most of the tests of the Stanford-Binet were loading heavily on a common factor.

The Stanford-Binet was revised in 1960 for the third time (Terman & Merrill, 1960). While no new content was introduced into this revision, the forms L and M were amalgamated into the Form L-M. Yerkes's (1917) and Wechsler's (1939) deviation IQs or standard scores were adopted in order to present the test results for the sample ages 2 through 18 years (the mean was 100 with a standard deviation of 16 rather than a standard deviation of 15). However, the concept of mental age was not fully rejected. The norm sample of

the 1937 group as well as a sample of 4498 subjects was utilized to evaluate changes in item difficulty and to establish the assignment of items on the new form (Sattler, 1992). Thorndike restandardized the 1960 revision, providing new interpretive norms in 1972, based on a more representative sample of 2100 non-white and white children (Sattler, 1988).

In 1986 the Stanford-Binet was revised into its fourth incarnation, in part, due to the drastic decline in use of the scale in the 1970s and 1980s (Lubin, Larsen, Matazzaro, & Seever, 1985). The Stanford-Binet: Fourth Edition (SB:FE) incorporates major revisions in the theoretical rationale and content of intelligence testing (Thorndike, Hagen, & Sattler, 1986b). While many item types were retained from the earlier Stanford-Binet scales, the SB:FE was very much a new test that shared only a modest overlap with its former versions. This revision attempted to cope with criticisms levelled at the Binet's former incarnations such as factor analytic studies which suggested the presence of group factors (e.g. Ramsey & Vane, 1970; Thompson, 1984) and disapproval of the Binet's overemphasis of verbal abilities (Krohn & Lamp, 1989).

The greatest alteration to the SB:FE is a multiple subtest hierarchical model of intelligence based on contemporary psychometric theory (Thorndike & Lohman, 1990). Prior editions of the Stanford-Binet produced only a composite IQ. Although the pattern of right and wrong answers could be analyzed qualitatively, the earlier tests did not provide a basis for quantitative analysis of subcomponents of the entire scale. The SB:FE has up to 15 subtest

scores, four area scores, and a composite score based on the entire test (Thorndike et al., 1986a, b). This new model reflected a strong commitment to general intelligence, an acceptance of group factors, and recognition of both as being of value in educational applications.

To guide construction of this test the authors of the SB:FE implemented a three-level hierarchical model of the structure of cognitive abilities. The first level is general ability, or g, which the authors define as the "cognitive assembly and control processes that an individual uses to organize adaptive strategies for solving novel problems" (Thorndike et al., 1986a). The conceptualization of *g* by Thorndike et al. (1986a, 1986b) was similar to that proposed by Spearman (1904). Sampling widely from a broad range of cognitive tasks allowed the factors specific to any single subtest to diminish in importance, and thus the examinee's standing on the composite performance became an indirect reflection of the *g* factor of intelligence (Glutting, 1989).

The second level in the hierarchy appeared as a modified (by the SB:FE authors) Cattell-Horn view of intelligence (Horn, 1976, 1982; Horn & Cattell, 1966). However, in addition to the crystallized/fluid distinction proposed by Cattell and Horn, the test developers added a separate short-term memory factor (with separate visual, auditory, and kinaesthetic systems) derived from information processing theory (Baddeley, 1976; Vallar & Baddeley, 1982). The SB:FE therefore emphasized memory skills to a much greater extent than any other tests of general intelligence at that time. The crystallized-abilities factor

represents school related skills such as vocabulary and quantitative skills. The fluid-analytic abilities factor is largely the same as the Cattell-Horn construct of fluid intelligence and is a measurement of the cognitive skills necessary for solving new problems that involve nonverbal and figural stimuli. The fluid abilities factor was also similar to Wechsler's "native mental ability" (Schaie & Willis, 1991, p. 402), identified as the innate biological element of intelligence.

The third level is primarily pertinent to the crystallized-abilities factor which is split into two areas: verbal reasoning and quantitative reasoning. At this level, the fluid-analytic abilities are given the alternate label of abstract/visual reasoning. Thorndike and his associates acknowledge that these factors are included in the model because thy have special meaning to clinicians and educators (Thorndike et al., 1986b). The examiner obtains up to 15 subtest scores (vocabulary, comprehension, absurdities, verbal relations, quantitative number series, equation building, pattern analysis, copying, matrices, paper folding and cutting, bead memory, memory for sentences, memory for digits, and memory for objects) , 4 area scores (verbal reasoning, quantitative reasoning, abstract/visual reasoning, and short-term memory), and an overall composite standard age score which is, according to Glutting (1989), similar to Wechsler's Deviation IQ.

C. Psychometric Properties of the SB:FE

The SB:FE standardization sample consisted of 5013 individuals in 17 age groups (2 years to 23 years 11 months). The sample was devised to be nationally representative of the United States based on several variables including age, sex, ethnicity, geographic location, and community size (Thordike et al., 1986a). Socioeconomic status of the examinees was also monitored. Weighting procedures were used to overcome the discrepancy of overrepresentation of children from upper socioeconomic versus lower socioeconomic categories.

Reliability estimates for the SB:FE were provided by Thorndike et al. (1986a, 1986b). The Kuder-Richardson Formula 20 internal consistency reliability coefficients for the Composite, Reasoning Area, and subtest scores were also calculated and ranged from .80 to .99 (median estimate of .97), depending on the area and age group. The most reliable score was considered to be the Composite standard Area Score (SAS) (Thorndike et al., 1986b). Reliability estimates for the subtests were lower than the estimates obtained by the total test and four Reasoning Area SAS's.

Thorndike et al. (1986b) provided evidence for construct validity by focusing on three types of evidence which include: correlations among the subtests (further clarified by factor analysis); correlation of the SB:FE with other tests deemed to measure similar constructs; and examination of the performance of groups on the SB:FE identified by indices or criteria other than the SB:FE.

Thorndike et al. (1986b) maintained that factor analysis supports a number of theoretical dimensions of the scale including adequate to high *g* loadings of the subtests. Further evidence of construct validity was provided by correlating scores with other individual intelligence tests such as the Stanford-Binet: Form L-M (Terman & Merrill, 1973), Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974), and Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1983).

D. Appraisal of the SB:FE

The SB:FE has several positive characteristics including good validity, high reliability, good standardization, excellent administrative procedures, guidelines, test materials, and helpful scoring criteria (Sattler, 1992). The SB:FE also incorporates a large number of very easy items on most subtests which allows the examiner to establish a more precise picture of low functioning children, mental retardation, and brain damaged individuals (Gregory, 1992). Most competing instruments such as the WAIS-R bottomed out at Full Scale IQs in the mid-50s (Wechsler, 1981).

The SB:FE has many limitations. There is a lack of comparable battery throughout the age ranges covered by the scale (Sattler, 1992). This limitation is embedded in scores obtained by children of different ages which were based on different combinations of subtests (Thorndike et al., 1986a, 1986b). This lack of continuity across ages and within subtests makes it difficult to monitor changes

in performance on individual subtests and can make it difficult to perform longitudinal studies (Sattler, 1988). The SB:FE also fails to provide the same range of Composite scores, factor scores, or subtest scores throughout the age levels of the scale (Gregory, 1992). There is confusion regarding the factorial structure and there is difficulty scoring responses, which can lead to halo effects in scoring and contribute to examiner bias (Gregory 1992; Sattler, 1992). The SB:FE can also take an extremely long time to administer because only one subtest is timed (Sattler, 1992).

E. The Stanford-Binet: Fifth Edition (SB5)

The Stanford-Binet Intelligence Scale-Fifth Edition (SB5) currently represents the most recent edition of an assessment tool that has a long history of clinical utility. The SB5 is an individually administered assessment of intelligence and cognitive abilities that may be used for individuals between the ages of 2 and 85. The complete scale, the Full Scale IQ (FSIQ), consists of 10 subtests, which, in a number of configurations, provide other scales, namely the Nonverbal IQ (NVIQ), based on nonverbal subtests, and the Verbal IQ (VIQ), based on verbal subtests. The Nonverbal and Verbal IQs are each based on the five cognitive factors evaluated by the SB5: Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory.

The factor indexes are based on the research of Cattell (1971), Horn (1994), and Carroll (1993). The research of Cattell, Horn, and Carroll has been

named the CHC theory (McGrew & Woodcock, 2001) or the Gf-Gc theory by Horn and Noll (1997). According to the manual the SB5 factors are supported by this theory as having evidence of construct validity. These facors were included because they have the highest g loading among cognitive subtests (Roid & Barrum, 2004). The substantiation of strengths and weaknesses of an individual's profile allow the assessor to make decisions about a particular child in order to design interventions to help remediate weaknesses and magnify strengths (Roid, 2003c).

The nonverbal subtests can be used to assess individuals who are deaf or hard of hearing, as well as those with communication disorders, autism, specific learning disabilities, a limited English language background, traumatic brain injury, and other conditions such as aphasia or stroke (which may hamper linguistic ability). The SB5 places more emphasis on nonverbal abilities when compared to earlier editions in order to minimize, for at least part of the test, the demand for expressive language. The Verbal IQ (VIQ) is based on the five Verbal subtests associated with the five cognitive factors. The Verbal IQ is used for the standard, Full-Scale administration and is also useful in evaluating special cases in which the examinee may have limited vision, orthopedic impairment, or other conditions that interfere with the completion of the NVIQ.

The SB5 items are calibrated according to difficulty level so that each testlet covers a range with easy items first and a non-overlapping progression of difficulty from level to level. Scores from the routing subtests (Nonverbal Fluid

reasoning routing subtest is Object Series/Matrices and the Verbal Knowledge routing subtest is Vocabulary) also direct the examiner to appropriate items in later portions of the test. This system of routing and levels is much like computerized adaptive testing which adapts the difficulty of items to the ability level of the examinee. This is believed to increase the accuracy of measurement (Haladyna & Roid, 1983; Weiner, 1990).

According to the manual, the items included in the final edition of the SB5 were chosen based on multiple sources of information, item analysis, and specific criteria. These criteria include freedom from gender and cultural bias based on statistical indexes of potential item bias; fit of items to the Rasch model of each of the five factors in the battery; recommendations from examiners in the pilot, tryout, and standardization studies; high subtest internal consistency, interscorer reliability, and discrimination indexes for items; functional ability range; positive contribution to the factor structure; and evidence of construct, criterion, and content validity (Roid, 2003c).

F. The SB5 Factor Indexes

The five factor indexes that contribute to the verbal, nonverbal, and full-scale IQs are designed to measure the abilities that contribute to intelligence. As researchers have identified more discrete domains of intelligence, interpretation of intelligence tests began to emphasize the individual's performance in more narrow domains of cognitive functioning, as well as possible differences in the

developmental trajectories of these domains (Goldstein & Hersen, 2000). The SB5, according to the manual, measures five of the 10 broad (Stratum II) factors, derived from the CHC theory, based on the research by Cattell, Horn, and Carroll (in McGrew, 1997). These factors are considered to have the highest *g* loading in the CHC model and are recognized as important features of higher-order thinking and general reasoning ability (Benbow & Lubinski, 1996). Other factors of the CHC model were evaluated during test construction but were omitted from the SB5 because they increased the difficulty of test administration, added too much time, and had lower priority in terms of reasoning skills.

The factors and their definitions are adapted from Roid (pp. 41-44, 2003c) and Roid and Barrum (in Kaufman & Kaufman, 2004):

i. Fluid Reasoning. Several theories of cognitive functioning emphasize the importance of fluid reasoning (Carroll, 1997; Cattell, 1963; Cattell & Horn, 1978; Sternberg, 1995). Tasks that require fluid reasoning involve the process of "manipulating abstractions, rules, generalizations, and logical relationships" (Carroll, 1993, p.583). Fluid Reasoning (FR) is described as the ability to solve verbal and nonverbal problems using inductive or deductive reasoning. Activities that assess fluid reasoning require the individual to determine the underlying rules or relationships among pieces of information that are novel. Items were created to be relatively independent of school-based knowledge or prior experience and, rather, focus on

comprehension of figural or verbal relationships that are not bound by cultural knowledge (Carroll, 1993). The ability to reason inductively requires the individual to reason from the specific to the general. In deductive reasoning, the individual is given general information and is required to form a conclusion or specific example. The testlets of the SB5 that tap into FR abilities include: Matrices, Verbal Absurdities, Object Series, Early Reasoning, and Verbal Analogies. Interestingly, the newest version of the WISC-IV incorporates new subtests designed to measure fluid reasoning ability (Matrix Reasoning, Picture Concepts, and Word Reasoning which produce the Perceptual Reasoning Composite [Wechsler, 2003]).

ii. Knowledge. Knowledge (KN), also called crystallized ability, is a person's general fund of information acquired in a variety of contexts such as home, school, work, and daily life. It involves learned material that has been acquired and stored in long-term memory. Although it is highly related to educational attainment, it is more general than reading or academic skills learned in school. It includes understanding of the universe, natural laws, objects in nature, animals, people, and facts from everyday life. The testlets that measure KN include Vocabulary, Procedural Knowledge, and Picture Absurdities.

iii. Quantitative Reasoning. Quantitative Reasoning (QR) represents an individual's ability with numerical problem-solving and numbers. Prior research on the development of mathematical concepts in children (Huttenlocher, Jordan, & Levine, 1994) and the developmental progression (Geary, 1996) of these skills was utilized when developing these items for the SB5. The SB5 emphasizes applied problem-solving over specific mathematical knowledge learned in school. Many of the activities in the testlets measure quantitative reasoning.

i.v. Visual-Spatial Processing. Visual-Spatial Processing (VS) quantifies the ability to see patterns, relationships, spatial orientation, or the whole among diverse pieces of the visual display. People skilled in VS can understand directions within a three-dimensional world and explain them to others. Activities found in the testlets that evaluate visual-spatial processing are those involving position and direction, form boards, and form patterns.

v. Working Memory. Working Memory (WM) is a subset of memory processes in which assorted information stored in short-term memory is evaluated, sorted, and transformed. The idea of working memory is derived from theories such as those of Baddeley (1986) and research has shown the importance of working memory in terms of school learning and frequently deficient in those with learning disabilities (Reid, Hresko, & Swanson,

1996). Working memory, as a construct, has been depicted as a key feature of reasoning ability (Kyllonen & Cristal, 1990). Many activities in the testlets of the SB5 included working memory tasks such as Last Word and Block Span.

G, Psychometric Properties of the SB5

All information regarding the psychometric properties of the SB5 are derived from the *Stanford Binet Intelligence Scales, Fifth Edition, Technical* Manual (Roid, 2003c). The norming sample of the SB5 consists of 4800 subject between the ages of 2 and 85+, and was collected over a 1 year period (between 2001 and 2002). The sample is considered to be representative of the United States population and is matched to percentages of the stratification variables (age, sex, race/ethnicity, geographic region, and socioeconomic level) identified in the U.S. Census Bureau (2001) publication. Additional to the 4800 cases incorporated in the normative sample, several special groups were also tested including: 104 ADHD, 108 Autistic, 114 Developmental Disability, 76 Limited English, 202 Gifted, 373 Learning Disabled, 26 Motor impaired, 154 Mentally retarded, 128 Speech/Language Impaired, 36 Deaf/Hard of Hearing, and 44 Seriously Emotionally Disturbed individuals (Roid, 2003c). Roid and Barrum (2004) did note that there is concern about the development of the SB5 in terms of covering all disabilities (or subtypes) and all possible correlated tests in the SB5 validity studies. While the SB5 included 1 365 subjects with

exceptionalities or clinical diagnoses in it standardization sample, this large collection of subjects still could not cover all special education categories.

Reliability estimates are provided in the *Technical Manual for the Stanford-Binet Intelligence Scale, Fifth Edition* (Roid, 2003c). Coefficients for the Full Scale IQ range from 0.97 to 0.98 and are quite consistent across age groups. The Abbreviate Battery IQ has reliability coefficients that average 0.91 across the age groups. The Verbal and Nonvebal IQ have average reliability coefficients of 0.95 to 0.96, while the factor indexes all have average coefficients above 0.90. The factor indexes are of higher reliability than the subtests (range from 0.72 to 0.94 depending on the subtest and age range). Test-retest stability (reliability) was also calculated for each of four age groups (2-5, 6-20, 21-59, 60 -85+) at a time interval of 5-8 days. The stability of the Full Scale IQ was high ranging from 0.93 to 0.95, the Nonverbal and Verbal IQ coefficients ranged from 0.89 to 0.95, with a median of 0.93. Subtest test-retest correlations ranged from 0.66 to 0.93. There is also high interscorer agreement with polychotomous items (score of 0,1, or 2) which are found in four of the five SB5 factors, ranging from 0.74 to 0.97 with a median value of 0.90.

Validity is partly measured by the accumulation data with regard to the uses and interpretations of tests scores. Since the SB5 is a new test and the acquisition of data takes time, supplementation of SB5 score interpretation will depend on evidence published in the future, such as in studies similar to this

research dissertation. The developers of the SB5 provide evidence of content, criterion-related, and construct validity. Each is explored briefly.

Content validity indicates the degree to which questions, tasks, or items on a test are representative of the behaviour the test was designed to sample (Gregory, 1996). When the SB5 was developed, feedback was provided by researchers and experts in assessment, as well as the examiners from the developmental phases of the test. To provide consistency with the nature of items from past editions, an inclusive item bank was created and contained all items from prior editions. These items were rated for their consistency in measuring the cognitive factors of the SB5. All items were rated by experts in the Cattell-Horn-Carroll (CHC) (Evans, Floyd, McGrew, & Leforgee, 2001) theory during the initial phases of the SB5 development. Factor analysis of the SB:FE also confirmed items and subtests most essential to each of the factors (Thorndike, Hagen, & Sattler, 1986a). The SB5 subtests they do correlate highly with other psychological or educational assessment batteries, ranging from 0.84 to 0.89. Item analysis, subtest scaling analysis, reliability studies, and factor analysis were also conducted (Wright & Lineacre, 1999).

Evidence of criterion-related validity, which is demonstrated when a test is shown to be effective in estimating an examinees performance on some outcome measure (Gregory, 1996), was also collected. The relationship between the SB5 and SB:FE was established and it was found that there is a high correlation between the SB5 Full Scale IQ and SB:FE Composite Age

Score (0.90).The SB5 Full Scale IQ also correlates relatively highly with the Form L-M (0.85). The SB5 has also been correlated to the Wechsler intelligence scales. The SB5 Full Scale IQ was found to have a correlation of 0.84 with the Full Scale IQ of the *Wechsler Intelligence Scale for Children-Third Edition* (WISC-III) (Wechsler, 1991). The Verbal IQ and Nonverbal IQs of the SB5 correlated 0.85 and 0.66 with the Verbal and Performance IQs, respectively. The SB5 was also correlated with the *Wechsler Adult Intelligence Scale-Third Edition* (WAIS-III) (Psychological Corporation, 1997). The correlations range from 0.82 (between the SB5 FSIQ and WAIS-III FSQ) to 0.81 (between SB5 VIQ and WAIS-III VIQ) and .76 (between SB5 NVIQ and WAIS-III PIQ). The SB5 has also been correlated with the *Woodcock-Johnson III Tests of Cognitive Abilities* (Woodcock, McGrew, & Mather, 2001c). The Correlation between the SB5 FSIQ and Woodcock Johnson III General Intellectual Ability Standard is 0.78. The SB5 was also correlated with various measures of achievement including the *Woodcock-Johnson III Tests of Achievement* (Woodcock, McGrew, & Mather, 2001b) with correlations ranging from 0.50 to 0.84 and the *Wechsler Individual Achievement test-Second Edition* (Psychological Corporation , 2001) with correlations ranging from 0.33 to 0.83.

Construct-related evidence of validity refers to the appropriateness of inferences about the underlying construct made, based on the test administered (Gregory, 1996). According to Roid (2003c), differences in SB5 scores across age groups provides construct validity because the SB5 was created to measure

developmental growth and life-span changes. Intercorrelations between the subtests, factor indexes, and IQ scores also are provided in the *Technical Manual* (Roid, 2003). Evidence for general ability or *g* (Carroll, 1993; Spearman, 1927) was given using principal component analysis (Roid, Prifitera, & Weiss, 1993). Confirmatory factor analysis in which all loadings exceed 0.40 and cross battery factor analysis further emphasize the construct related validity.

H. The Wechsler Scales

The Stanford Binet cannot be described without a brief discussion of the Wescher Scales because these two instruments have been major competitors within the testing market. Wechsler's original test, the Wechsler-Bellevue, was based on the principle that intelligence is a global unit because it characterizes the individual's behaviour as a whole. However, it is also specific because it is composed of elements or abilities that are distinct from each other. Wechsler selected and developed subtests that highlighted the cognitive aspects of intelligence that he thought were important to measure. Based on clinical experience he included verbal comprehension, abstract reasoning, perceptual organization, quantitative reasoning, memory, and processing speed. All of these have been identified by Carroll (1993, 1997) and Horn (1991) to be important facets of cognitive ability. Wechsler divided subtests into verbal and performance tasks for practical purposes rather than based on a two-factor structure of intelligence (Wechsler, 2003). More current revisions of the

Wechsler scales have highlighted the measures of more discrete domains of function, such as processing speed and working memory. Wechsler's earlier versions of his intelligence tests have demonstrated evidence of scale validity based on their correlations with other measures of cognitive ability including the *Kaufman Assessment Battery for Children (*Kaufman & Kaufman, 1983) and the *Woodcock-Johnson III Test of Cognitive Abilities* (Woodcock, McGrew, & Mather, 2001). The development of the Wechsler scales were primarily based on practice and clinical experience and some authors have stated that "it is a matter of luck that many of the Wechsler subtests are neurologically relevant" (McFie, 1975, p.14).

As the Wechsler scales were progressively modified new editions began to incorporate more subtests. The third edition, the *Wechsler Intelligence Scale for Children-Third Edition* (WISC-III; Wechsler, 1974) continued this practical and clinical process. In addition to the traditional Verbal IQ, Performance IQ, and Full Scale IQ, the WISC-III included four new index scores, namely, Verbal Comprehension Index, Perceptual Organization Index, the Freedom from Distractibility Index, and Processing Speed Index. The structure of the *Wechsler Intelligence Scale for Children-Fourth Edition* (WISC-IV; The Psychological Corporation, 2003) also provides four index scores and a Full Scale IQ, but no longer utilized a Verbal or Performance IQ. The four index scores are slightly different and include a Verbal Comprehension Index, Working Memory Index, Processing Speed Index, and Perceptual Reasoning

Index. This new Wechsler scale was developed based on theory, clinical research, and factor analytic studies, which is a significant departure from the prior editions.

The new test framework utilized for the development of the WISC-IV is based on the theoretical foundation of the concepts of fluid and crystallized intelligence, developed by Carroll (1997), Cattell (1943, 1963), Cattell and Horn (1978) and Sternberg (1995). The new Wechsler scale is utilizing the same framework that the Stanford-Binet Scales have employed for the last two decades, at least. This suggests that the producers of the Wechsler scales acknowledge the relevance of the CHC theory in the testing field (Roid, 2005). It appears that these two tests are converging to a significant degree now that the theoretical foundations are mirrored.

Section IV

Profile Analysis of Children with ADHD

There is, at present, a dispute in the field of intelligence assessment over whether specialists should explore strengths and weaknesses in subtest and composite performance for achievement and intelligence measures. One view provides empirical and statistical evidence against profile analysis (Jensen, 1992; McDermott et al., 1992; Zacharay, 1990), whereas the divergent viewpoint supports the procedure based on the clinical evidence of the reality of profiles existing in populations with exceptionalities (Kaufman &

Lichtenberger, 2000; Pfiefferet al., 2000; Sattler, 1992). The following section explores the debate surrounding profile analysis; the reasons why the practice persists, and evaluation of studies that have examined profiles of children with Attention Deficit Hyperactivity Disorder (ADHD). Much of the research available concerning the debate of profile analysis focuses on the Wechsler scales and is highly limited in terms of the use of the Stanford-Binet scales.

Exploration of strengths and weaknesses in subtests and composite/index performance on intelligence and achievement measures is a widespread practice in the field of psychology. Sattler (1992) describes the process of profile analysis as involving the interpretation or analysis of the pattern of subtest scaled score performances or deviations between test composite for an individual subject or for a particular group of individuals with an exceptionality. Profile analysis is done in order to attempt to identify strengths and weaknesses and to describe unique ability patterns. This analysis may drive the formation of hypotheses about performance and aid in the diagnosis of exceptional populations such as those with specific learning disabilities, mental retardation, and emotional/behavioural disorders (Pfieffer, Reddy, Kletzel, Schmelzer, & Boyer, 2000). Profile analysis may also be used for treatment planning decisions for children (Pfieffer et al., 2000).

The custom of profile analysis has become so ubiquitous in the field of school psychology that many practitioners regularly, and often automatically, search for profiles for all of their clients. Pfieffer and his colleagues (2000)

found that 89% of nationally certified school psychologists surveyed for their study (n= 354) regularly used profile analysis and 70% listed it as the most beneficial feature of the WISC-III. Psychologists depend on profile analysis in order to supply a better understanding of client's individual needs and aid in differential diagnosis. While this type of analysis is popular, it is essential that psychologists are aware of the approaches, issues, and debates that surround the search for strengths and weaknesses in subtest and index performance.

1. Profile Analysis Debate

Since the development of multiscore test batteries such as the Stanford-Binet and Wechsler scales, there has been a dispute over the practice of profile analysis and ipsative scoring (Stanton & Reynolds, 1999, 2000). Authors such as McDermott et al. (1992) provide empirical and statistical evidence against the use of profile analysis while others, such as Kaufman (1979, 1994a) and Kaufman and Lichtenberger (1999, 2000), support the procedure based on clinical evidence of the existence of profiles in exceptional populations. Pfieffer et al. (2000) reported that many psychologists regularly incorporate the practice of profile analysis as part of scoring and evaluating intelligence measures.

There is a tendency among psychologists who administer and score numerous standardized protocols to believe that subtests, factor, and composite scores provide valuable information in the diagnosis and understanding of an

individual's ability (Kehle, Clark, & Jensen, 1993). In addition, profile analysis (of subtests and composites) is utilized by most psychologists in order to maximize the amount of information generated from the time-consuming process of intelligence evaluation (Konold et al., 1999). Practicing psychologists have a tendency to believe that the composites and subtests can assist them in designing interventions which may improve a child's cognitive performance (Kehle et al., 1993). McDermott et al. (1992) warn against the profile analysis stance when interpreting measures such as the WISC-III because it ignores the fact that the test is based upon the concept of general intelligence (*g*) and that subtests and factor composites only contribute to this overall concept.

Profile analysis is often performed because there is an entrenched belief that knowing an individual's particular strengths and weaknesses on the composites and/or subtests will lead to better diagnosis and the development of effective interventions (Zacharay, 1990). However, Wechsler scales were developed to provide an overall estimate of general ability and do not connect results with interventions (Zachary, 1990). Additionally, efforts to remediate skills on an individual test may only increase the child's ability to take a particular subtest and may not change general ability or the level of intelligence (Jensen, 1992). MacMann and Barnett (1994a) have stated that the Wechsler scales, and other measures of general intelligence are "a costly and ineffective use of professional skills" (p.224). Rather than focusing on outdated methods of

measuring intelligence, it is recommended that we look at alternative means that will help us increase learning in more naturalistic settings (MacMann & Barnett, 1994b; Naglieri, 1999a).

Kaufman and Lichtenberger (1999, 2000) and Kaufman and Kaufman (1994b) reject this criticism with the argument that it is not the responsibility of the Wechsler, or other measures of general intelligence, to provide intervention recommendations, but, rather, the clinician's responsibility to develop these interventions. Kaufman (1979) also believes that there are harsh limitations when just depending on the general IQ when diagnosing and endeavouring to understand individuals. Kaufman and Lichtenberger (1999) indicated that examination of the verbal-performance discrepancy does not provide enough information for comprehending the performance of some individuals. Instead, they propose that the subtests are unique and reflect distinct human abilities. Kaufman, from these conclusions, began to support the ipsative process of understanding strengths and weaknesses through an individual's performance n the composites and/or subtests. He projected that profile analysis could help us understand how children learn; their strengths and weaknesses; and how information gained by other methods relates to performance on scales of general intelligence (in particular, the Wechsler scales).

Naglieri (1988) provides a commentary on the utility of subtest profile analysis with the Stanford-Binet, Fourth Edition. He states that the Stanford-Binet-Fourth edition is a multiscore instrument for which interpretation of

individual strengths and weaknesses based on subtest profile analysis is appropriate. He also states that the technical manual recommends pairwise comparisons between subtests and Area scores and when comparing Area and Composite scores there are many disadvantages. Naglieri declares that the pairwise comparisons suggested by the manual (Thorndike, Hagen, & Sattler, 1986a) are problematic in that practitioners usually do not make one pairwise comparison, but several. When more than one comparison is made the probability of interpretive error is increased by the number of comparisons made. For example significance changes from 0.05 to 0.15 when three pairwise comparisons are made (e.g. Vocabulary and Comprehension, Matrices with Pattern Analysis, and Absurdities with Verbal Relations at the 0.05 level). Given the large number of possible pairwise comparisons, the probability that the practitioner will find one or more "significant" subtests can be very large (Naglieri, 1988). Instead, Naglieri advocates for the ipsative approach in which making a comparison between each subtest score and the average subtest score is more appropriate. This approach has been applied to other intelligence tests such as theWechsler scales (Sattler, 1982), the Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1983), and the McCarthy scales of Children's Abilities (Naglieri, 1982). The advantage of the ipsative approach is that the number of comparisons is reduced and the overall error rate can be appropriately reduced.

Kaufman (1979, 1990, 1994b) and Kaufman and Lichtenberger (1999, 2000) developed a widely used ipsative and profile analysis procedure for evaluating an individual's pattern of strengths and weaknesses that is regularly applied towards the interpretation of the Wechsler scales. They suggest that practitioners perform the following steps during the process of scoring and interpreting the WISC-III: 1.) calculate the Full Scale IQ, Performance IQ and Verbal IQ, 2.) calculate the Verbal-Performance IQ discrepancy, four factor indexes (verbal comprehension, perceptual organization, freedom from distractibility, and processing speed), 3.) evaluate the discrepancies between the indexes, 4.) calculate the individual strengths and weaknesses in subtest performance; and 5.) generate hypotheses regarding the pattern in index and subtest performance.

Although the SB5 Full Scale IQ is a good measure of general intellectual ability, the IQ by itself tells little about the underlying scores upon which it is based. The profile analysis of the Stanford–Binet, Fifth Edition follows the same steps for the Wechsler scales. Roid (2003c) indicates that the factor indexes of the Stanford-Binet, Fifth Edition are useful for studying the meaning of profile differences because they are based on the Cattell-Horn-Carroll (CHC) theory (Carroll, 1993; Cattell, 1963,1966, 1971; Horn, 1994), which provides a strong research basis for the SB5 factors and their high reliability provides users with confidence in interpreting profile scores. Roid (2003c) notes that because factor reliability is greater than subtest reliability, the interpretation of factor

profile patterns is an important and reliable starting point for the analysis of the SB5 after the general level of IQ scores have been calculated.

Stanford-Binet, Fifth Edition interpretation includes examining the pattern of subtest scaled scores within the Verbal scale, within the Performance Scale, and within the entire scale. Other assessments include the relationship between the Verbal Scale IQ and the Performance Scale IQ; relationships among the five index scores; and relationships among the subtest scaled scores (Sattler and Saklofske, 2001). Profile Analysis aims to describe the child's unique ability pattern and goes beyond the information contained within the Full-Scale IQ. Knowledge of ability pattern can help in formulating interventions. The goal of profile analysis is to generate hypotheses about the child's abilities. The hypotheses can be used to clarify the functional nature of the child's learning problems; arrive at treatment recommendations; develop educational programs; and recommend a vocational placement.

When doing profile analysis, it is important to remember that subtest and composites can be considered strengths or weaknesses even if they fall within the normal range when compared to other children in the same group. This is because ipsative scoring is based on the individual's performance and not the national norms (Kaufman & Lichtenberger, 2000). Once a child's profile has been developed it needs to be determined if the discrepancy is a strength or weakness that is uncommon in the general population. Even though the discrepancy may be statistically significant, if it occurs frequently in the

population it lacks practical significance and may be only due to chance or represent normally occurring individual differences (Bray, Kehle, & Hintze, 1998; Sattler, 1992). McDermott et al. (1992) state that practitioners have confused the process of normative and ipsative scoring. Normative scores such as the Full Scale IQ can be compared to the performance of the standardization sample. However, ipsative scoring alters the normative aspect of the data because individuals can only be compared to themselves (Zachary, 1990). Profile analysis moves ipsative scoring further by looking for a pattern of strengths and weaknesses that are frequently seen in specific exceptional populations and that distinguish them from other populations (Shelton, 1998).

After the examiner establishes whether the child displays practical and significant fluctuations in subtest performance, hypotheses need to be developed about possible diagnosis and cognitive strengths and weaknesses. This process requires that the examiner consider all information gathered from the intelligence measurements and from sources such as academic assessments, behavioural assessments, and background data (Kaufman, 1999; Kaufman & Lichtenberger, 2000; Sattler, 2002). Many authors state that unless there are multiple units of information then the hypotheses cannot be supported (Kaufman & Lichtenberger, 2000). In addition, these authors state that profiles cannot be utilized for differential diagnosis but as additional information in understanding the child's difficulties or behaviour.

2. Profile Patterns for Attention Deficit Hyperactivity Disorder

There are many individual and group administered standardized tests available for measuring general and specific areas of intelligence. The Wechsler Intelligence Scale for Children-Third Edition (WISC-III) and the Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE) are most frequently used by school and clinical psychologists to assess general intellectual functioning of referred children (Saklofske, et al., 1994). Although most of the research on profile analysis is concerned with the patterns displayed by children with learning disabilities, profile analysis with children who have Attention Deficit Hyperactivity Disorder (ADHD) are also debated. Most of the evidence that supports or denies the existence of profile patterns in children with ADHD comes primarily from data collected via the Wechsler scales.

Fiorello, Hale, McGrath, Ryan, and Quinn (2002) made a direct comparison of typical and atypical populations using the WISC-III. The authors used commonality analysis to evaluate unique and common factor predictors of Full Scale IQ (FSIQ) for children with variable profiles and those with flat profiles. FSIQ was composed of primarily shared variance for the flat profile group, however, unique variance was observed for the variable profile group which had a Learning Disabled sample and ADHD sample. Results suggest that FSIQ does not adequately represent global intellectual functioning and that it is necessary to look to other factors such as subtest scores to understand a child's unique cognitive functioning. Fiorello et al.'s (2002) results support clinicians

who examine an individual's pattern of index scores in addition to interpreting the FSIQ. Individuals with ADHD had the Verbal Comprehension Index and Perceptual Organization Index account for the majority of their variability. Full Scale IQs were found to be factorially complex and therefore interpretation of the FSIQ as a global measure could be problematic for this group.

Further support for examining subtest patterns comes from a study by Kaplan et al. (2000) who administered the short form of the WISC-III (vocabulary and block design) to children with ADHD, reading difficulties, and children with comorbid ADHD and reading difficulties. They found that the distributions of the estimated Full Scale IQs for each of the three groups did not differ significantly from a normal distribution, with the majority of children (50%) in each group scoring within the normal range.

It is well known that children with ADHD have difficulties with attention and concentration (Barkley, 1995, 1998). The debate is about whether children with ADHD display lower performance on the Wechsler scale subtests that are believed to measure these abilities. Particular focus has been placed on the Wechsler subtests that compose Freedom from Distractibility (FD) and the Processing Speed (PS) indexes. The standardization and normalization process for the WISC-III revealed that children with ADHD displayed lower performance on the PS (coding and symbol search) and FD (digit span and arithmetic) indexes (Wechsler, 1991). The lowest performance was exhibited on the coding and digit span subtests. The results suggest that children with ADHD

have difficulties on the subtests believed to measure attention, concentration, and speed of processing information. Further analysis revealed that the ADHD group tended to display a pattern of lower performance on the ACID (arithmetic, coding, information, digit span) subtests. The ACID profile was observed in 11.8% of the ADHD sample and 1.1% of the standardization sample. Additionally, when a partial ACID criterion was applied (any three of the ACID subtests) 27.9% of the ADHD sample displayed this profile as compared to 5.6% of the standardization sample.

Prifitera and Dersch (1993) also found the ACID profile to be more prevalent among an ADHD sample than in the WISC-III standardization sample. Snow and Sapp (2000) made a comparison of WISC-III scaled scores and subtest patterns for children with ADHD and the standardization sample described in the manual for children 6-16 years old. Consistently lower scores for the ADHD children on the SCAD Index (Symbol Search, Coding, Arithmetic, Digit Span) and ACID profiles (Arithmetic, Coding, Information, and Digit Span) suggested diagnostic utility.

Dickerson-Mayes, Calhoun, and Crowell (1998) explored the profile patterns of children with ADHD on the WISC-III in comparison to a group of children without ADHD. They found that the ADHD children displayed a pattern of lower performance on both the FD and PS indexes. This lower pattern of performance was not present in the non-ADHD group. Mealer, Morgan, and Luscomb (1996) also found that children with ADHD performed

significantly lower on the FD index when compared to a non-ADHD control sample. The results of both the Dickerson-May et al., (1998) and Mealer et al. (1996) supported previous research (e.g. Lufi & Cohen, 1985; Lufi, Cohen, & Parish-Plass, 1990) suggesting that children with ADHD do perform lower on the Wechsler subtests believed to measure attention and concentration. Assessmany et al. (2001) also used the WISC-III to explore the ability of this test to discriminate between a group of 40 children with ADHD and 40 non-ADHD children. A stepwise discriminant function analysis indicated that Digit Span, Information, Vocabulary, and Picture Completion contributed significantly to the prediction of ADHD group membership.

Schwean, Saklofske, Yackulic, and Quinn (1993) found that children with ADHD displayed average performance on the FD index but that this performance was significantly lower than the high average performance observed for the Perceptual Organization Index (picture completion, picture arrangement, block design, object assembly). The ADHD group also displayed poor performance on both the PS index and the subtests that composed the ACID profile. Further research by Saklofske, Schwean, Yackulic, and Quinn (1994) supported the lower performance on the Freedom from Distractibility index, the Processing Speed index, and the ACID subtest profile for children with ADHD.

Prifitera and Dersch (1993) explored the WISC-III profiles for children with ADHD as compared to the standardization sample. The ADHD group

displayed poorer performance on the freedom from distractibility and processing speed indexes when compared to the standardization sample. The group with ADHD also displayed lower performance on the ACID profile than the standardization sample. Further analysis revealed that the ADHD group and LD group in this study displayed poor performance on the same subtests. Prifitera and Dersch (1993) therefore advised against using subtest performance as the means for differential diagnosis between these two groups.

Anastopoulos, Spisto, and Maher (1994) reported that children with ADHD scored significantly lower on the FD index with performance on the arithmetic and digit span subtests significantly lower than the other subtest scores. Further analysis, however, revealed that only 27% to 53% of these children scored significantly lower on the FD index when compared to the verbal comprehension and perceptual organization indexes. As such, Anastopoulos et al. (1990) suggested that the freedom from distractibility index may not be as pure a measure of attention and concentration as previously believed. These researchers also noted that children with attention difficulties can do well in one-to-one situations. It is important to keep in mind that the individual conditions under which intelligence tests are given can enable these children to display normal performance on the proposed attentional subtests that compose the FD index.

In contrast, Gussin and Javorsky (1995) stated that low performance on the Freedom from Distractibility index was not characteristic of children with

ADHD. Their study found that the ADHD group performed in the average to low average range on the freedom from distractibility subtests and that the performance of the ADHD group was not significantly different from that of the non-ADHD group. Gussin and Javorsky concluded that the Freedom from Distractibility index measures something other than attention, hyperactivity, or impulsivity.

Reinke, Beebe, and Stein (1999) concluded that children with ADHD have a tendency to display lower performance on the Freedom from Distractibility index, but that this discrepancy did not occur often enough to aid in diagnosis. Barkley, DuPaul, and McMurray (1990) reported similar results as their data suggested that the freedom from distractibility index was not able to distinguish children with ADHD from those children that have ADD without hyperactivity. In addition, Semrud-Clikeman and Lorys-Vernon (1988) found that the freedom from distractibility index did not aid in differentiating between groups of children with ADHD, ADD without hyperactivity, and conduct disorder.

3. Non-Wechsler Profile Patterns

Profile analysis studies have been primarily focused on the utility of the Wechsler scales in identifying exceptional populations. However, there are other tools available for examining the cognitive features of children. While these assessment tools do exist, there is a paucity of research available in terms

of examining profile patterns of various groups of individuals. This section discusses the available research on profile patterns of children with ADHD on non-Wechsler scales.

Carter, Zelko, Oas, and Walton (1990) examined the profiles of ADHD children and clinical controls on the Kaufman Assessment Battery for Children (K-ABC). Carter et al. concluded that children with ADHD displayed lower performance on sequential processing tasks when compared to the control group. This lower performance was primarily due to the low scores found on the word order subtest of the K-ABC Sequential Processing scale. Even though the ADHD group's sequential ability fell within the normal range, it was a full standard deviation below the performance of the control group. This suggested that children with ADHD may display more difficulties with processing information in a specific serial order than with processing information as a whole. The ADHD children also scored lower on the WISC-R freedom from distractibility factor when compared to controls.

Quinlan and Brown (2003) evaluated if a brief measure of verbal memory can assess short-term verbal memory impairments relative to verbal abilities in adolescents and adults with attention-deficit/hyperactivity disorder (ADHD). They also intended to ascertain whether significant differences between short-term verbal memory and verbal abilities are more common among persons with ADHD than in the general population. Adolescents and adults diagnosed with ADHD were assessed with a measure of short-term verbal

memory. The short-term verbal memory score of each subject was compared with the verbal abilities on two measures. The percentages of ADHD subjects with a significant discrepancy between verbal IQ and short-term verbal memory were compared with the standardization sample for the verbal memory measure. The percentage of ADHD subjects with a significant discrepancy between these two measures greatly exceeded the percentage of persons in the general population showing such a discrepancy.

Cutting et al. (2003) examined the mechanisms underlying verbal learning in children with and without attention-deficit/hyperactivity disorder (ADHD). Children with reading disabilities were excluded from this study. Children, ranging in age from 6 to 16 years, with ADHD were compared to typically developing children on both process and product scores from the California Verbal Learning Test for Children. The findings indicated that children with ADHD initially learned the same number of words as controls but showed weaknesses recalling the words after delays. This suggests that children with ADHD are less efficient learners. These findings showed that children with ADHD can exhibit unexpected weaknesses in learning even without a formal learning disability.

Reardon and Naglieri (1992) examined differences in profile patterns on the Cognitive Assessment System (CAS) for a group of children with ADHD as compared to a control group and concluded that the ADHD group performed significantly lower than controls on all of the planning, attention, and successive

subtests. The low successive subtest performance is consistent with the Carter et al. (1990) findings of low successive processing skills for children with ADHD on the K-ABC. In addition, Reardon and Naglieri found that the ADHD group performed significantly lower on the attention composite than on the other three PASS processes. Reardon and Naglieri proposed that the ADHD group performed lower than controls on the planning and successive composites because of the impact that attention has on the more complex tasks that compose these composites. Lower planning performance was consistent with previous research suggesting that children with ADHD experience more difficulty when trying to form their own plans and complete complex tasks (Douglas, 1980; Whalen, 1983). Naglieri, Goldstein, Iseman, and Schwebach (2003) also confirmed that children with ADHD have impaired ability in the planning domain of cognitive function when compared to children without ADHD and those with anxiety/depression.

Despite the strong support presented by Naglieri, Das, and others for utilizing the CAS for diagnostic purposes, other researchers such as Kranzler and Keith (1999) warn against this practice. Kranzler and Keith re-examined the CAS standardization data using a confirmatory factor analysis procedure and concluded that the test does not consist of four separate factors. Instead, they proposed that the successive composite was the only one that can be interpreted separately and the other three factors were almost indistinguishable from each other. They concluded that the CAS evaluates possibly one or two broad

categories and three narrow categories just as the other, more traditional, intelligence measures. However, this argument can be made against other, current, intelligence measures which are used for differential diagnosis.

There are relatively few reports on the performance of ADHD children on the SB:FE. Saklofske et al. (1994) examined the profile patterns of children with ADHD on the WISC-III and SB:FE (abbreviated form). Quantitative reasoning and short-term memory scores on the SB:FE were found to be lower than abstract visual reasoning. Verbal reasoning was found to be more than 0.33 standard deviations above the mean. These results, according to Saklofske, partially contrast the WISC-III results which found verbal comprehension to be 8 points lower than perceptual organization. Overall, the Saklofske et al. (1990) study did not yield substantial information regarding profile patterns in children with ADHD and the results were difficult to interpret because there was no control group for comparison.

Roid (2003c) describes profile analysis interpretation with the Stanford-Binet-Fifth, Edition with Learning Disabled and ADHD children. He presents guidelines and recommendations for interpreting score patterns from the SB5 factor indexes and subtest profiles. He discusses the five factor index scores (Fluid Reasoning, Knowledge, Quantitative reasoning, Visual-Spatial Processing, and Working Memory) and the 10 subtest scaled scores (five verbal and five nonverbal) representing each of the five factors. It is important to note

that one third of a standard deviation (SD) of 15 is considered to be an educationally meaningful difference (Tallmadge & Wood, 1976).

In the manual, Roid (2003c) found that children with ADHD had the second highest overall factor scores relative to the other groups studied (LD-Reading, LD-math, LD-Writing) (LD-writing had highest mean scores, overall). The ADHDs lowest scores were in the Knowledge (KN) and Working Memory (WM) factors. This pattern was deemed to be similar to those found on the Wechsler intelligence scales (Prifitera & Dersh, 1992; Kaufman, 1994) where Information and Digit Span subtest scores were lowest in the profiles of children with ADHD. The low Working Memory scores were consistent for the ADHD group at the subtest level, with identical mean scaled scores in both the verbal and nonverbal areas and substantially higher scores in the nonverbal and verbal Quantitative Reasoning subtests. At the subtest level, Roid found that Fluid Reasoning and Knowledge were consistent across the verbal and nonverbal domains. Roid (2003c) concluded that the SB5 factor index and subtest scores have potential for displaying clinically and educationally relevant patterns of cognitive strengths and weaknesses. He stated that patterns of factor index scores were associated with membership in special groups such as ADHD or LD. According to Roid, the Working Memory index provided the most significant information about group membership. The Woodcock-Johnson III tests of cognitive abilities, which is also based on the CHC theory also provides

support for the utility of the SB5 factor indexes in identifying strengths and weakneses (Ford, 2002).

Conclusions

This literature review suggests that three major issues affect our understanding of children with ADHD and their unique cognitive patterns. First, ADHD is a complex disorder that not manifested uniformly at the cognitive level. Second, intelligence as a construct is a complex issue which is difficult to operationalize for the purposes of quantifying. Third, that the current studies evaluating intelligence and specific cognitive patterns of children with ADHD present variable results that make conclusions difficult to make in the context of providing specific cognitive profiles for these children. The Stanford Binet-Fifth Edition has not been used in an independent study to examine the profile patterns and individual scores of children with ADHD. This study intends to explore the utility of the SB5 for the purpose of identifying the special cognitive characteristics of children with ADHD.

Section V

Hypotheses

The following hypotheses were generated on the basis of what has been reported in this literature review regarding the overall and specific intellectual functioning of children with ADHD-Combined Subtype relative to controls on various measures of cognitive ability. The hypotheses generated from this general goal pertain to the specific dependent variables evaluated.

When possible, directional hypotheses have been provided. Brief summary statements about the supporting evidence and relevant authors from this chapter are offered. Most hypotheses are based on the Full scale, Nonverbal, Verbal, and Factor scores. Hypotheses at the subtest level will only be provided for the Working Memory factor because there is supportive research on verbal and nonverbal aspects of working memory.

Hypothesis 1: The mean Full Scale IQ score for the ADHD group will not differ significantly from the mean FSIQ score for the Control group.

This hypothesis is supported by research utilizing the WISC-III, which suggested that the estimated Full scale IQs of children with ADHD or Learning Disabilities did not differ significantly from a normal distribution (Fiorello et al., 2002; Kaplan, 2000). While Tannock (1998b) reported that ADHD is typically associated with a lower full scale IQ, and some deficits on specific subtest of the

WISC-III, the mean levels of intellectual functioning fall well within the normal range.

Hypothesis 2: The mean Verbal IQ score of the ADHD group will be significantly lower than the mean Verbal IQ of the Control group.

Barkley (1998, 2000) indicated that verbal subtests (from the WISC-III) place children with ADHD at a disadvantage. This position has been confirmed by a number of studies that indicate children with ADHD score lower on verbal subtests, especially those that contribute to the Verbal Comprehension Index of the WISC-II or WISC-III verbal subtests that load heavily on working memory (Anastopoulos et al., 1994; Fiorello et al., 2002; Prifitera & Dersch, 1993; Schwean et al., 1993).

Hypothesis 3: The mean Nonverbal IQ score of the ADHD group will not differ significantly from the mean Nonverbal IQ of the Control group.

Schwean et al. (1993) found that the performance of children with ADHD did not differ significantly from controls on the nonverbal subtests that constitute the Perceptual Organization Index. These authors, as well as Fiorello et al. (2002), indicated that nonverbal scores of children with ADHD were generally in the normal range. While children with ADHD do more poorly on WISC-III nonverbal tasks that are timed, the SB5 does not have timed subtests and this issue should not significantly affect the ADHD group. Reardon and

Naglieri (1992) found that children with ADHD perform better on tasks that require simultaneous processing, a factor reflected in many of the nonverbal tasks.

Hypotheses 4.1-4.5: The Factor Indexes

Hypothesis 4.1: The Fluid Reasoning mean factor score of the ADHD group will not differ significantly from the Fluid Reasoning mean factor score of the Control group.

A study presented in the manual by Roid (2003c) reported that the mean Fluid reasoning factor score for children with ADHD did not differ significantly from the mean factor scores of the normative population.

Hypothesis 4.2: The Knowledge mean factor score of the ADHD group will not differ significantly from the Knowledge mean factor score of the Control group.

The manual by Roid (2003c) reported that when using the SB5, it was found that the mean Knowledge factor score for the ADHD group when compared to the normative population, was not statistically significant.

Hypothesis 4.3: The Quantitative mean factor score of the ADHD group will not differ significantly from the Quantitative mean factor score of the Control group.

The manual indicates that Roid (2003c) reported that the mean Quantitative Reasoning factor scores for children with ADHD did not differ significantly from the mean factor scores of the normative population.

Hypothesis 4.4: The Visual Spatial Processing mean factor score of the ADHD group will not differ significantly from the Visual Spatial Processing mean factor score of the Control group.

The Visual Spatial Processing index includes many tasks that appear to require simultaneous processing skills. Studies using assessment tools that evaluate these skills indicate that ADHD children do as well as controls (e.g. Reardon & Naglier, 1992). Roid (2003c), according to the manual, also found that children with ADHD have comparable Visual Spatial Processing factor scores when compared to the normative group.

Hypothesis 4.5: The Working Memory mean factor score of the ADHD group will be significantly lower than the Working Memory mean factor score of the Control group.

Based on Barkley's Behavioural Disinhibition Theory (1997b), children with ADHD are expected to manifest deficits in working memory ability. Baddeley (1986) further clarifies the nature of these deficits within his Working Memory model. Baddeley indicated that working memory deficits are most commonly observed in tasks which depend on simultaneous storage and

processing, while simple storage and rehearsal tasks (short-term memory) are relatively unimpaired (Karatekin, 2004; Roodendrys et al., 2001). Therefore, when testing children with ADHD, measures of working memory, versus short-term memory, are expected to be more sensitive to working memory deficiencies, particularly if the measures of working memory are not dependent on academic knowledge (Roid & Barrum, 2004). In tests of working memory both verbal and nonverbal deficits are manifest in ADHD children (Barnett et al., 2001; Karatekin, 2004).

CHAPTER 3

Research Design and Method

Overview

This study explores and compares the profile patterns of children with ADHD and normal controls using the Stanford-Binet Fifth Edition (SB5). This study employs an ex post facto design, comparing the archival data of 29 participants with ADHD-Combined subtype to 50 participants, without ADHD, in the Control group. All participants were administered the SB5 as part of a comprehensive educational assessment at an Educational Clinic at a large Western Canadian University. The mean Full Scale IQs were analyzed and compared using Analysis of Variance (ANOVA). The Verbal and Nonverbal IQs, factor scores, and scaled subtest scores of the two groups were analyzed and compared using Multivariate Analysis of Variance (MANOVA). Discriminant function analysis was employed to test if group membership could be predicted based on the SB5 scores.

Procedure

Data Collection

The design of this study was an ex post facto design using archival data gathered through a university based psychology training clinic specializing in assessment and counselling. The initial data were collected by graduate students enrolled in the Fall/Winter and Spring/Summer sessions of a graduate level

individual assessment course at a large Canadian university. Student clinicians perform the assessments and the participants' utilize the services of the clinic with the understanding that the information gathered from the assessments may be used for teaching and research purposes. Prior to testing, the child's guardians or parents signed consent forms which allow for their data and file information to be used for research purposes. The clinicians explained to the clients during the consent procedures that authorization of use of their information in the research is completely voluntary and independent from the assessment procedure itself. Permission to complete this study was granted by the ethics committee of the Department of Educational Psychology.

After the assessments were completed, doctoral level supervisors or chartered psychologists examined the protocols and reports to ensure the accuracy of test administration, scoring, interpretation, and report writing. Each instrument was administered and scored according to standardized procedures indicated in the respective test manuals. The SB5 does not have Canadian norms and, hence, the American norms determined the resultant scores.

Protocols, test results, and final reports were examined individually and the data were collected from the client files by the researcher. The researcher had no contact with the study participants and the clinician's assessments were completed independently from the research study. In order to maintain confidentiality, participants' names were replaced with codes. The records used for this study were selected from evaluations completed between May, 2003 and

January, 2005. Initially, the archival file data for all children tested with the Stanford-Binet, Fifth Edition were entered into a computer database. The files were then culled to identify cases in which the individuals had been administered the full length SB5, the Behaviour Assessment Scale for Children (BASC), and an academic measure (such as the Wechsler Individual Achievement Test-Third Edition, Woodcock-Johnson-Second Edition, or Wide Range Achievement Test). The full length SB5 data provided scores for the Full Scale IQ, Verbal IQ, Nonverbal IQ, the five factors (Knowledge, Fluid Reasoning, Working Memory, Visual-Spatial Processing, and Quantitative Reasoning), as well as the 10 subtest scores derived from the five factors based on verbal and nonverbal skills. The database and original files were then checked by a second individual (graduate student) in order to establish the integrity of the data and correct any errors found.

Sample

Identification of ADHD-Combined Subtype.

The files of each participant between the ages of 5 years, 0 months and 17 years, 11 months were reviewed to determine if the individual met the Diagnostic and Statistical Manual of Mental Disorders, Fourth edition (DSM-IV, American Psychiatric Association: APA, 1994) criteria for a diagnosis of ADHD-Combined subtype. These criteria include a persistent pattern of inattention and hyperactivity/impulsivity, which is considered developmentally

inappropriate for a child's age or developmental level and are evident prior to the age of seven. Evidence of clinically significant impairment in social, academic, or occupational functioning in at least two or more contexts was necessary for inclusion. Symptoms had to persist for at least 6 months and it was essential to rule out disorders including Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder, Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder.

The triad of behaviours characterizing ADHD includes inattention, hyperactivity, and impulsivity (Barkley, 1994). ADHD can be grouped into three distinct subgroups, namely, ADHD-Predominantly Inattentive Type; ADHD-Predominantly Hyperactive-Impulsive Type; and ADHD-Combined subtype. Within the DSM-IV, inattentiveness is manifested as a failure to give close attention to details or making careless mistakes in schoolwork or other tasks. Individuals find it difficult to keep persisting with tasks until completion and may appear that they are not listening to or hearing what has been said to them. Situations that require sustained mental effort are difficult for children with ADHD and are viewed as aversive. It is for these reasons that ADHD is frequently noted in contexts where children are placed in situations which require sustained attention; unstimulating repetitive tasks; or in structured settings such as the school classroom (Barkley, 1997).

Hyperactivity is demonstrated by excessive fidgetiness; squirming in one's seat; not remaining seated when required to do so; appearing to be "driven

by a motor"; having difficulty playing or engaging quietly in leisure activities; or by excessive talking. School aged children manifest many of these symptoms whereas adolescents and adults may not demonstrate as many overt symptoms of hyperactivity (Wender, 1994). Adolescents and adults may, instead, have difficulty engaging in quiet sedentary activities or be overwhelmed by feelings of restlessness. As observable signs of hyperactivity are relative to the individual's age and developmental level, the DSM-IV recommends that care should be taken not to confuse hyperactivity with behaviours demonstrated by normally active, young children.

Impulsivity is manifested by blurting out answers to questions before the question has been fully completed; inability to delay responses; difficulty waiting for turns in games or group situations; and interrupting or intruding on others to the extent of causing problems in social, academic, or occupational functioning (APA, 1995).

To diagnose ADHD a set number of behavioural indicators must be noted in each of the Inattentive and Hyperactive-Impulsive categories. The minimum number of behavioural indicators suggestive of each subtype is six (APA, 1995). When a child demonstrates 6 or more out of 9 criteria across both categories, a diagnosis of ADHD-Combined Type is considered.

The application of the DSM-IV diagnostic criteria for ADHD remains subjective. The DSM-IV (APA, 1995, pp.83) suggests using multiple

informants who provide a confluence of observations regarding the child's behaviours in a variety of settings.

Further inclusion criteria were applied to the participant with a diagnosis of ADHD (see below).

Criteria for Inclusion and Exclusion:

Multiple diagnostic methods and information services were used to determine whether the participants fit into one of the two diagnostic categories (ADHD-Combined subtype or Control/normal). Each participant's results were carefully reviewed by means of a detailed diagnostic process. Based on specific research criteria, the participants were included into the two group categories or excluded from the study. The criteria for inclusion into the ADHD-Combined subtype matched the DSM-IV criteria outlined by the American Psychiatric Association (1994; 2001). For a child to be considered as having ADHD-Combined Type and qualify for inclusion, they must have demonstrated a "persistent pattern of inattention and hyperactivity impulsivity' (APA, 1994, p.85)

Attention Deficit Hyperactivity Disorder: In addition to meeting the DSM-IV criteria (APA, 1994; 2001) the following conditions were also met: Two different raters of the BASC Parent Rating Scale (PRS) and/or Teacher Rating Scale (TRS) scored the individual on the Attention Problems and Hyperactivity Problems Scale T-score $\geq$ 60. Clinician-observed indications of

inattention and/or hyperactivity/impulsivity also must have been seen (indicated in the behavioural observations section of the final report). For a diagnosis of ADHD there was a requirement of the absence of a major psychological disorder as indicated by a) the clinical interview, b) the general information and history questionnaire, and c) no clinically significant Scale elevations (T scores $\geq$ 70) on both raters BASC TRS and PRS clinical scales. These clinical scales include the evaluation of the following behaviours: aggression, anxiety, atypicality, conduct problems, depression, somatization, and withdrawal. There also could be no other conditions impairing cognitive functions such as a SB5 Full Scale IQ score < 75 or the presence of a learning disability (achievement scores in academic areas such as reading, mathematics, or written expression must not have been more than 1.5 standard deviations below the norm). English was required to be the primary language of the participants, and they must have been attending school on a full-time basis. In addition, participants could not be on any stimulant medication since it is believed to have an impact on attention and concentration (Nieoullon, 2002).

Controls: Participants in the Control group must not have met the criteria for a learning disability or ADHD, and no presence of conditions impairing cognitive function as reported by the general information and history questionnaire or the clinical interview. The mean SB5 Full Scale scores were >75. The participants' primary language was required to be English and they must have been attending school full-time basis. The participants were not to

have any major psycho-educational disorder and the BASCs should not have indicated any clinically significant scores on the subtest scales (T score $\geq$ 70) for aggression, anxiety, attention problems, atypicality, conduct problems, depression, hyperactivity, somatization, or withdrawal scales.

The behavioural measures are essential to this study as they help identify the behavioural issues that are associated with ADHD and rule out comorbid emotional and/or behavioural conditions that could affect the data set. The achievement measures were included to rule out comorbid learning problems/disabilities that would potentially impact the cognitive results.

Final Composition of Participants in Present Study

The participants in this study were selected from an initial non-random, clinical sample of 202 children: 119 males (58.9%) and 83 females (41.1%) aged 5 years 0 months to 17 years 11 months and going to primary or secondary school. These individuals were referred for psychoeducational assessment to a testing and training clinic between the years 2003 and 2005. Each child was assessed with the SB5; parent and teacher forms of the Behavioural Assessment for Children (BASC); and academic measure (WIAT-II, WJ-III, or WRAT-3); a developmental history; and semi-structured interviews with the children, parents, and teachers.

It is clinically relevant to include the 5 to 17 year age range which is representative of the school-age population. This age range also matches the

data collected for children with ADHD during the SB5 norming process (Roid, 2003b). Participants were referred to the clinic for psychoeducational assessment by parents, teachers, general medical practitioners, pediatricians, school counselors, and other health professionals. Referrals are typically made to determine the strengths and weaknesses of each child by evaluating learning, behavioral, and/or emotional functioning. It is important to note that many referrals are made by parents who do not have significant concerns about their child's cognitive, academic, or behavioral deficits, but are curious about their child's general ability.

The initial sample was examined to identify children who had received a diagnosis of ADHD-combined subtype and children who were considered to be "normal." One hundred and forty-five (72%) children from the original sample did not meet the criteria for ADHD-Combined subtype and 57 (28%) did meet these criteria.

Further exclusionary criteria were used to create a relatively pure ADHD-Combined type group and Control group. Children were evaluated with parental interviews, observations, medical histories, and through assessment for possible comorbid psychological or neurological disorders that may have affected intellectual functioning. Such disorders included learning disabilities, epilepsy, Fetal Alcohol syndrome, Autism, and head injury. These disorders may impact intellectual processes and complicate the interpretation of the data (Korkman, Kettunen, & Autti-Ramo, 2003). Children with ADHD-Inattentive

subtype (n=26) and ADHD-Hyperactive subtype (n=5) were also excluded from this study. Of the children with the ADHD-Inattentive subtype, twelve were taking medication and five had comorbid conditions, leaving nine participants for analysis, an insufficient number for the statistical procedures being applied in this study. Children were also excluded if they were taking medication at the time of testing. One child was excluded from the Control group because he/she was not enrolled in school at the time of assessment. Six children were excluded from the Control Group because they did not have parent-completed BASC's. The final sample used for testing the hypotheses in this study consisted of 29 children with ADHD-Combined subtype and 50 children in the Control group. Reasons for exclusion of participants from the final study are presented in Table 3.1 and 3.2.

Table 3.1

Frequency and Percentage of Participants Excluded from the ADHD-Combined Group

	ADHD-C (n=57)	
	f	%
Interfering Diagnosis		
Learning Disability	7	12.3
FAS	1	1.8
Autism	1	1.8
Mild Mental Retardation	1	1.8
Multiple Conditions	3	5.3
Medication	13	22.8

Table 3.2

Frequency and Percentage of Participants Excluded from the Control Group

	Control (n=145)	
	f	%
Interfering Diagnosis		
Learning Disability	18	12.9
Mild Mental Retardation	11	7.9
Multiple Conditions	19	13.1
Traumatic Brain Injury	1	<1.0
Cerebral Palsy	1	<1.0
Severe Emotional Disturbance	2	<1.0
ADHD-Inattentive Type	26	17.9
ADHD-Hyperactive Type	5	3.4
Medication	1	<1.0
English Language Learner	5	3.4
Incomplete Files	6	4.1
Not Enrolled in School	1	<1.0

The demographic information presented in the next chapter indicates that the sample used in the current study is similar to participant samples used in other studies. While this study has the general ratio of males to females as seen in other studies' clinical samples (1.9:1) it is not comparable to the gender ratio seen in the general population or regular clinical samples which range from 3.6:1 (Barkley, 1994) to 9:1 (Cantwell, 1996). Another difference between this study and other studies is that it controls for medication use and the existence of comorbid conditions that may affect cognitive results. However, comorbid conditions and psychostimulant use is common among those who suffer from

ADHD (Barkley, 1998; Cantwell, 1994; Weyandt, 2001) and the findings of this study may not generalize well to the ADHD population as a whole. This study differs from other studies in that it takes effort to evaluate only children with ADHD of the Combined type rather than children with ADHD in general, which includes both the inattentive and hyperactive subtypes. This issue has made it difficult to interpret many prior studies (e.g. Roid, 2003c) which do not delineate these subtypes.

Instrumentation

I. Intelligence Measure: The Stanford-Binet, Fifth Edition (SB5)

The SB5 (Roid, 2003b) is an individually administered test of general intelligence and cognitive abilities. The norms are provided for ages 2 through 85+ based on a standardization sample of 4,800 people representative of the gender, ethnic, regional, and educational levels of the U.S. shown by the 2000 Census. The standardization sample included 3,000 additional individuals from a variety of special populations (e.g., gifted, MR, developmental delay, LD, ADHD, Speech/Language problems, Deaf).

The SB5 consists of ten subtests (formed by crossing two domains-verbal and nonverbal-with five factors) each with a mean of ten and standard deviation of three. Composite scales formed by various combinations of subtest scores (Full Scale IQ, Verbal IQ, Nonverbal IQ, and five Factor Indexes) have a mean of 100 and SD of 15. The Full Scale IQ is representative of the "general

ability to reason, solve problems, and adapt to the cognitive demands of the environment' (Roid, 2003b, p.5). Verbal IQ consists of verbal subtests, which measure language-based abilities. Nonverbal IQ consists of nonverbal subtests, which measure non-language abilities. The five factors assessed by the SB5, which are assessed both in the verbal and nonverbal domains, and that contribute to the factor scores include Fluid reasoning (FR), Knowledge (KN), Quantitative Reasoning (QR), Visual-Spatial Processing (VS), and Working Memory (WM). The SB5 can also produce additional special scores, including Change Sensitive Scores (providing an objective level of ability, regardless of age) and Age Equivalent scores (based on Change Sensitive Score values).

The SB5 has been examined in terms of correlational studies with WISC-III and WAIS-III and a number of other measures (including, but not limited to, the SB-IV, SB-LM, WPPSI-R, Bender-Gestalt II) which are included in the Technical Manual (Roid, 2003b). Correlations between the SB5 IQ scores and the Wechsler Intelligence measures (WPPSI-R, WISC-III, and WAIS-III), which provide criterion-related validity range from .66 to .85. Correlations between the SB5 factor index scores and the Wechsler Intelligence measures ranges from .42 to .81. Predictive validity was established by the test authors by evaluating the extent to which the SB5 predicts academic achievement. The correlation between the SB5 IQ scores and the Woodcock-Johnson III tests of achievement (WJ-III) range from .65 to .84. The SB5 was correlated with the Wechsler Individual Achievement Test-II (WIAT-II) and the IQ scores

correlations ranged from .42 to .83. Contruct validity, the evidence that test scores accurately portray their intended construct (Gall, Gall, & Borg, 2003), was provided through the intercorrelations of test results with various special groups (Roid, 2003c). When the standardization sample was examined it was found that scores on the various SB5 factors was predicted by deficits associated with the disorder. Of 104 children that received a diagnosis with ADHD, it was found that they scored significantly lower on the WM and KN factor scores (Roid, 2003c).

Reliability coefficients range from .84 to .91 for individual subtests, .90 to .92 for factor indexes, and .91 to .98 for IQ scale scores. It also has high test-retest stability ranging from .76 to .94.

Additional features of the SB5 include the following characteristics (Roid, 2003b): it includes a wide variety of items requiring nonverbal performance by examinee which is important for assessing individuals with limited English, deafness, or communication disorders; the comprehensive measurement of five factors-Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory, which provide a more complete assessment of individual intelligence; the ability to compare verbal and nonverbal performance believed to be useful in evaluating learning disabilities; greater diagnostic and clinical relevance of tasks, such as verbal and nonverbal assessment of working memory; includes Full Scale IQ, Verbal and

Nonverbal IQ, and Composite Indices spanning 5 factors with a standard score mean of 100, SD 15; and it includes subtest scores with a mean of 10, SD 3 .

The factor scores are described in Chapter 2 extensively, so only the verbal and nonverbal subtests for each of the five factors are further described in this section. (Adapted from Roid, 2000c, pp. 9)

Nonverbal Subtests.

1. Nonverbal Fluid Reasoning: This subtest score is composed of items that measure the skills associated with answering novel problems presented in nonverbal form (object series/matrices). These abilities do not depend on academically or culturally dependent learning. Inductive and deductive reasoning skills are employed to identify analogical patterns and visual sequences.
2. Nonverbal Knowledge: Individuals are required to produce oral explanations of absurdities shown in the test materials to be occurring in different contexts. This subtest depends on the individual's fund of general information obtained through school learning and culturally-dependent situations.

3. Nonverbal Quantitative Reasoning: Tests mathematical knowledge and the application of logical thinking to solving quantitative problems presented in pictorial form.
4. Nonverbal Visual-Spatial Processing: The individual completes a picture by assembling its parts. This measures visualization, assembly skills, and spatial reasoning.
5. Nonverbal Working Memory: This nonverbal subtest assesses the ability to store, transform, and retrieve visual information in short-term memory.

Nonverbal subtests.

1. Verbal Fluid Reasoning: The individual's ability to solve novel verbal problems and orally present correct explanations of the solutions to these problems is evaluated.
2. Verbal Knowledge: This is a vocabulary-based subtest which measures word knowledge and language development. This skill set has been found to be one of the best predictors of general ability and success in a variety of settings.

3. Verbal Quantitative Reasoning: Problems are presented verbally to assess a variety of abilities including: mathematical conceptualization, identification of mathematical relationships, and logical reasoning.
4. Verbal Visual-Spatial Processing: The individual provides verbal explanations of spatial relationships seen in illustrations and heard in verbal descriptions. This subtest measures visualization and spatial reasoning.
5. Verbal Working Memory: Like the nonverbal working memory subtest, this subtest measures the ability to store, transform, and retrieve information from short-term memory.

II. Achievement Measures

1. The Weschler Individual Achievement Test- Second Edition (WIAT-II): The WIAT-II (Psychological Corporation, 2001) was used to assess academic performance. The assessment process with the WIAT-II takes approximately 40-70 minutes with young children. It can be used on children in the pre-kindergarten age (age 4) through to grade 12 and beyond (age 85). It assesses multiple academic domains including reading, mathematics, written language,

and oral expression. The WIAT-II is a standardized instrument normed on a large sample with age and grade-based norms available in addition to standard scores. The reliability of the WIAT-II is moderately high to high with average reliability coefficients ranging from .80 to .98. The overall total composite reliability is .98. Test-retest reliability is very good (.85-.99 depending on the subtests) though there may be a slight elevation (between 1 and 3 standard score points) at the time of second testing (between 7 and 45 days). The WIAT-II has good reported content, construct, and criterion related validity, available from many studies cited in the manual.

2. *Woodcock-Johnson-Third Edition (WJ-III):* The WJ-III is based on the Cattell-Horn-Carroll (CHC) theory of cognitive abilities and is comprised of the Tests of Cognitive Abilities and the Tests of Achievement (Woodcock, McGrew & Mather, 2001). These two co-normed batteries provide a highly accurate and valid diagnostic system and can be used on individuals from preschool to adulthood. The WJ-III Tests of Achievement has two parallel forms (A and B) that are divided into two batteries—Standard and Extended. The Standard Battery includes tests 1 through 12 that provide a broad set of scores. The 10 tests in the Extended Battery provide more in-depth diagnostic information on specific academic strengths and weaknesses. Examiners can administer the Standard Battery either alone or with the Extended Battery. The WJ-III was normed on a nationally (American) representative sample of 8, 818

subjects. The subtest reliabilities of the WJ-III range from .80 or higher to .90 or higher. Test-retest reliabilities of broad clusters range from 0.92 to 0.96.

3. Wide Range Achievement Test-Third Edition (WRAT-3): The Wide Range Achievement Test-Third Edition (WRAT-3) is an individually administered test of achievement that is often used as a screener for potential learning problems. The WRAT-3 is an achievement test for children from the age of 5 to adults of the age of 74 years. It samples performance in three areas: spelling, reading, and arithmetic. The spelling subtest measures the ability to write words from dictation; the reading subtest measures the ability to read single words; and the arithmetic subtest measures written and oral mathematical computation and problem solving. The test takes approximately 20 minutes to administer to a child. The standard score mean is 100 and the standard deviation is 15. The test-retest reliability range from 0.94 to 0.96 for the 7 to 10-year-old age group, and 0.79 to 0.90 for the 13 to16-year-old age group. With respect to the validity of the test, research generally suggests that the validity is adequate (Sattler, 1992); however, Sattler (1992) suggest that the WRAT-3 should only be used for screening purposes because it has not been stratified on socioeconomic status and the reliability data is minimal.

III. Behavioural Measures

1. Behaviour Assessment System for Children (BASC): The BASC is believed to have clinical utility in terms of its ability to diagnose ADHD (Manning & Miller, 2001; Ostrander et al., 1998). Vaughn et al. (1997) and Ostrander et al. (1998) found the BASC Teacher and Parent Rating forms to be superior in their ability to distinguish ADHD children from non-ADHD children. Manning and Miller (2001) emphasize that the results of the BASC should never be used as the sole diagnostic tool, but rather, should be employed as part of a multidimensional assessment.

The BASC (Reynolds & Kamphaus, 1992) is a multidimensional measure of adaptive and problem behaviors and has versions for preschool (4–5), child (6–11), and adolescent (12–18) age levels. Each of the 130 items of the child version of the BASC is rated on a 4-point frequency scale ranging from never to almost always. Scores are measured as T-scores with an average of 50 and a standard deviation of 10. Scores are considered clinically significant (suggesting a high level of maladjustment) if they are two standard deviations above the mean ($\geq$70). The 95% confidence interval, which is the range within which the true score is likely to be, is calculated by adding or subtracting two standard errors of measurement to the observed T-score.

The BASC has three different forms: the Teacher Rating Scale (TRS), the Parent Rating Scale (PRS), and the Self-Report Inventory (SRP). The BASC is intended to measure aggression, hyperactivity, conduct problems, oppositional

behaviour, social skills, attention, anxiety, depression, and school-related behaviours rated on a Likert scale by individuals that interact with the child. There are parent and teacher versions available for the age ranges 6-11 and 12-18 and they take about 15-20 minutes to complete.

The TRS was developed for teachers and includes items that are particularly relevant to the classroom and school context. The PRS was designed for use by parents and includes items that are relevant to the home context. The SRP was created for children and adolescents and is made up of items that are pertinent to the child's own experiences, feelings, and beliefs. Scores are entered into a computer program and scoring and interpretation is completed by that program. The BASC has been standardized on a large, diverse sample and has good reliability (0.80-0.90).

The BASC has acceptable criterion-related validity when correlated with other behavioural measures (Reynolds & Kamphaus, 1992; Sandoval & Echandia, 1994). It has been correlated with the Achenbach (1991) Teacher Report Form, the Revised Behaviour Problem Checklist (Quay & Peterson), the Conner's rating Scales (Conners, 1989), and the Behaviour rating profile (Brown & Hammill, 1983).

Data Analysis

The independent variables, which are categorical in nature, are the two groups evaluated in this study: children with ADHD-Combined subtype and the

Control group (i.e. Children with no ADHD or other psychological or learning disorders).

The quantitative dependent variables in this study include: Full Scale IQ (FSIQ), Verbal IQ (VIQ), Nonverbal IQ (NVIQ), 5 Factor Indexes (Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory), and 10 factor index subtest scores.

Descriptive statistics for the demographic information and SB5 scores are provided. The Full Scale IQs for the ADHD and Control groups were analyzed and compared using the Analysis of Variance (ANOVA) procedure in the Statistical Package for Social Science program, Version 13.0 (SPSS; SPSS Inc., 2005). The Verbal IQ, Nonverbal IQ, and factor scores of the two groups were analyzed and compared using Multivariate Analysis of Variance (MANOVA) procedure. The MANOVA procedure was selected because it incorporates two or more dependent variables (Verbal and Nonverbal IQs, Factor Scores, and subtest scores) in the same analysis, allowing for a more powerful test of differences among means, and because correlations exist among the dependent variables (Fraenkel & Wallen, 2000). The between subject characteristics met the required criteria for using the MANOVA procedure (Onweugbuzie & Daniel, 2003). The criteria include: (1) observations are independent of one another, (2) the independent variables are categorical, (3) the dependent variables are continuous and interval, (4) unequal group sizes are accounted for and adjusted, (5) there is an adequate sample size, (6) homoscedascity was

evaluated using Box's Test of Equality of Covariance Matrices, and (7) the variables follow multivariate normal distributions (Tatsuoka, 1971). There are many test statistics produced when performing MANOVAs; for the purposes of this study the Hotelling's Trace (τ) was employed because the dependent variables are related to each other (Onweugbuzie & Daniels, 2003). Further analysis was conducted using stepwise dicriminant function analysis in order to test if group membership could be predicted based on the SB5 scores.

CHAPTER FOUR

Results

Statistical analysis consisted of descriptive statistics (e.g. means and standard deviations) as a method for examining demographic information and the means and standard deviations of the composite scores (Full Scale IQ, Verbal IQ, Nonverbal IQ), factor (Knowledge, Quantitative Reasoning, Fluid Reasoning, Working Memory, Visual-Spatial Processing) scores, and the subtest scores. Analysis of variance was used to evaluate between-group differences (ADHD-C and Controls). Full Scale IQ (FSIQ) scores were analyzed using the ANOVA procedure. Verbal IQ (VIQ) and Nonverbal IQ (NVIQ) and the factor scores were analyzed using a one-way MANOVA. Individual subtest scores were analyzed using a one-way MANOVA. As recommended by Hummel and Sligo (1971), a two-stage significance testing procedure was used for the MANOVAs.

A stepwise dicriminant function analysis was used to investigate if group membership could be predicted on the basis of scores available from the SB5. This is a way of examining significant multivariate effects by performing a dicriminant analysis for each of the significant effects (Tatsuoka, 1971). A discriminant analysis is a procedure that maximizes the separation between groups on some categorical variable by finding the optimal linear combination of several continuous variables. Discriminant function analysis is the inverse of a one-way MANOVA. The levels of the independent variable for MANOVA become the categories of the dependent variable for discriminant analysis, and the dependent variables of the MANOVA become the predictors for discriminant

analysis. In MANOVA we ask whether group membership produces reliable differences on a combination of dependent variables.

It is important to note that at the time of testing a Canadian standardization sample for the SB5 was unavailable. All scores are calculated based on the American standardization sample of the SB5 (Roid, 2003).

I. Descriptive Statistics: Demographic Information

The sampling process resulted in the selection of 79 children: 29 participants in the ADHD-Combined subtype group (ADHD-C) and 50 participants in the Control group.

The mean age of the entire sample was 10.43 years (SD=3.07 years). Ages ranged from 5.11 years to 17.89 years. The mean age of the children in the ADHD-C group was 10.42 (SD = 3.11), while the mean age of the Control group was 10.44 (SD = 3.08). All children included in this study were, at the time of assessment, attending school. The school grade range was from kindergarten up to grade 12.

The gender make up was 37 female (46.8%) and 42 male (53.2%). The male (N=19) to female (N=10) ratio in the current sample of ADHD-C children (1.9:1.) is not consistent with the proportion of males to females with ADHD-C in the general population (3.6:1; APA, 1994). In clinical samples, the ratio is believed to be even greater (9:1; Cantwell, 1996). The Control group consisted of 23 males and 27 females.

Table 4.1

Comparison of Male and Female Mean IQ Scores and Factor Scores for Children with ADHD-C

	Males (N = 19)		Females (N =10)		
	M	SD	M	SD	*t*
IQ Scores					
FSIQ	97.42	10.12	96.90	6.56	-0.154
NVIQ	96.95	12.03	96.30	7.88	0.174
VIQ	98.05	10.11	99.80	7.76	-0.518
Factor Scores					
FR	101.68	10.42	103.90	11.14	-0.520
KN	91.95	12.71	94.40	8.63	-0.614
QR	98.84	12.17	99.20	5.99	-0.106
VS	103.21	10.99	97.00	10.34	1.504
WM	90.42	8.17	94.50	7.23	-1.379

The cognitive performance of males and females diagnosed with ADHD-C was compared to determine the presence of gender differences. A two-tailed test with a corrected alpha level set at .01 was performed rather than MANOVAs because the sample sizes did not meet the criteria necessary to perform this type of statistical procedure. Results are presented in Table 4.1.

No significant differences between the two groups were evident on any of the IQ or Factor scores. Therefore, the impact of gender is not considered

relevant in the current study. The same analysis was performed on the subtest scaled scores and the results do not suggest any statistically significant differences between the genders at the subtest level. These results are presented in Table 4.2 .

Table 4.2

Comparison of Male and Female Mean Subtest Scaled Scores for Children with ADHD-C

	Males (N = 19)		Females (N =10)		
	M	SD	M	SD	*t*
Nonverbal Scaled Scores					
FR	9.68	2.67	11.50	2.51	1.127
KN	8.42	3.01	9.00	1.83	0.755
QR	9.95	2.92	9.90	1.79	0.019
VS	10.79	1.72	9.50	2.22	1.879
WM	6.79	2.76	7.50	2.22	-1.200
Verbal Scaled Scores					
FR	10.84	2.04	10.40	1.89	0.558
KN	8.68	2.45	9.20	1.99	0.224
QR	9.74	1.97	9.80	1.32	-0.578
VS	10.37	2.36	9.50	2.84	-0.200
WM	9.26	2.73	10.20	2.04	-0.302

Table 4.3

Means and Standard Deviations of the Achievement Scores for the ADHD-C and Control Groups

	ADHD-C		Control	
	M	SD	M	SD
WIAT-II*				
Math	86.53	16.76	100.50	13.78
Reading	93.92	17.96	103.87	12.67
Spelling	92.61	15.40	102.12	7.41
WJ-III**				
Math	87.86	10.71	98.89	9.68
Reading	90.43	7.13	103.11	17.99
Spelling	91.00	13.37	102.50	14.40
WRAT-3***				
Math	93.44	9.73	89.43	16.01
Reading	95.89	12.24	94.04	16.11
Spelling	98.33	6.58	94.52	13.50

*ADHD-C N = 13, Controls N = 9, ** ADHD-C N = 7, Control N = 18, *** ADHD-C N = 9, Control N = 23

The achievement scores of the ADHD-C and Control group were examined. Previous studies have suggested that children with ADHD-C experience greater difficulties in school (Campbell & Baker, 1991). The data is presented in Table 4.3. Achievement score ranges are presented in Table 1 in the

Appendix. In this study, there is some evidence that children with ADHD-C experience greater difficulties with academic subjects when compared to Controls when examining the mean achievement scores on the Woodcock Johnson-III and the WIAT-II. Performance of the children with ADHD-C on the WRAT-3 was similar to the performance of the Controls. However, these results could not be evaluated for significance because of the sample characteristics (did not fulfill criteria required to perform t-tests or MANOVA) and may also be an artifact of the tests themselves. The number of children in the Control group tested with the Wechsler Individual Achievement Test-Second Edition (WIAT-II) = 9, with the Woodcock Johnson-Third Edition (WJ-III) = 18, and with the Wide Range Achievement Test-Third Edition (WRAT-3) = 23. The number of children in the ADHD-C group tested with the WIAT-II = 13, with the WJ-III = 7, and the WRAT-3 = 9.

The scores on the Behaviour Assessment Scale for Children (BASC) Parent and Teacher completed forms were important in this study as they provided essential information when selecting which participants were included in this study. The expectation was that once the groups were selected based on the scores obtained on the BASC scales, there would be clear differences in at least the hyperactivity and attention domains, with children with ADHD-C receiving significantly higher scores than the Controls. A two-tailed test with a corrected alpha level set at .01 was performed. The results for the Teacher completed BASCs are in Table 4.4.

Table 4.4

T-Score Means and Standard Deviations Scores of the Children with ADHD-C and Controls on the Teacher-Completed Behaviour Assessment System for Children

	ADHD-C (N=29)		Controls (N=50)		
	M	SD	M	SD	*t*
SCALE					
Hyperactivity	65.67	13.49	47.91	8.29	-5.40*
Aggression	54.95	6.88	49.72	9.08	-2.25
Conduct	55.47	8.11	48.70	7.37	-3.02*
Anxiety	55.62	10.03	48.97	7.89	-2.57
Depression	57.29	14.67	46.63	6.13	-3.16*
Somatization	49.43	9.39	46.19	5.57	-1.43
Attention	67.58	7.62	54.53	7.96	-5.87*
Learning	59.30	13.56	57.03	8.79	-1.55
Atypicalty	56.57	12.46	47.78	5.35	-3.05*
Withdrawal	54.81	11.89	49.03	7.32	-1.99

Note. d.f.=77; *Significant at <.01 level

Table 4.6 indicates that on the BASCs completed by the teachers, children with ADHD-C have significantly higher scores (p <.01) on the Hyperactivity and Attention scales, with mean T-scores of 65.67 (SD = 13.49) and 67.58 (SD =

7.62) respectively, while the Controls had mean T-scores of 47.91 (SD = 8.29) for Hyperactivity and 54.53 (SD = 7.96) for Attention. Scores that are greater than 60 on the BASC are considered to be in the abnormal range. Scores that are less than 60 are considered acceptable and within the normal limits. There were also significant differences with children with ADHD-C having higher mean T-scores on the Conduct, Depression, and Atypicality scales of the BASC. However, these score were below 60 and are still considered to be within normal limits. The BASC also has a Parent version. The results are presented in Table 4.5.

Table 4.5

T-Score Mean and Standard Deviations Scores of the Children with ADHD-C and Controls on the Parent-Completed Behaviour Assessment System for Children

	ADHD-C (N=29)		Controls (N=50)		
	M	SD	M	SD	*t*
SCALE					
Hyperactivity	71.14	12.49	47.00	9.96	-8.18*
Aggression	57.82	11.24	48.35	9.53	-3.45*
Conduct	58.75	12.77	51.23	9.46	-2.51
Anxiety	53.77	16.20	51.24	10.14	-0.74
Depression	58.82	14.16	51.76	14.19	-1.85
Somatization	50.09	8.46	47.76	8.85	-0.99
Attention	70.91	7.89	53.68	8.94	-7.47*
Atypicalty	52.23	9.43	46.78	6.99	-2.53
Withdrawal	50.64	11.69	50.70	10.51	0.02

Note. d.f.=77; *Significant at <.01 level

Table 4.5 indicates that on the BASCs completed by the parents, children with ADHD-C have significantly higher scores (p <.01) on the Hyperactivity and Attention scales, with mean T-scores at 71.14 (SD = 12.49) and 70.91 (SD = 7.89) respectively, while the Controls had mean T-scores of 47.00 (SD = 9.96) for Hyperactivity and 53.68 (SD = 8.94) for Attention. As described before, scores that are greater than 60 on the BASC are considered to be in the abnormal range.

Scores that are less than 60 are considered acceptable and within the normal limits. There were also significant differences with children with ADHD-C receiving higher mean T-scores on the Aggression scale. Children with ADHD-C had a mean score 57.82 (SD = 11.24) which is very close to the cutoff score of 60. The children in the Control group had a much lower mean T-score at 48.35 (SD = 9.53). Information regarding family socioeconomic status (SES) and ethnicity was unavailable for the majority of participants and was not analyzed in this study.

II. Descriptive Statistics and Hypothesis Testing: SB5 Data

The main purpose of this research study is to assess the patterns of scores obtained at various levels (FSIQ, VIQ, NVIQ scores, Factor Index scores, and subtest scores) of children with ADHD-C and without ADHD-C on the SB5. The following null hypotheses were generated for the purpose of statistical testing of the overall and specific intellectual functioning of children with ADHD-Combined Subtype compared to the Controls on various measures of cognitive ability. The overall goal of this study is to evaluate the cognitive profiles generated by these two groups and search for potentially meaningful differences in those profiles. The hypotheses generated from this general goal pertain to the specific dependent variables evaluated.

The independent variables, which are categorical in nature, are the two groups evaluated in this study: children with ADHD-Combined subtype and the Control group (i.e. Children with no ADHD-C or other psychological or learning

disorders). The dependent variables are the scores obtained on the SB5 Composites including the Full Scale IQ (FSIQ), Nonverbal IQ (NVIQ), and Verbal IQ (VIQ); the 5 factor scores including Fluid Reasoning (FR), Knowledge (KN), Quantitative Reasoning (QR), Visual Spatial Processing (VS), and Working Memory (WM); and 10 subtests scores (Nonverbal: FR, KN, QR, VS, WM; and Verbal: FR, KN, QR, VS, WM). Effect sizes are calculated as Cohen's Delta (*d*) ($d = M_1 - M_2 / \sigma_{pooled}$) because there are only two groups (Cohen, 1988). Cohen (1988) defined effect sizes as: small, $d = 0.0 - 0.4$, medium, $d = 0.5 - 0.7$, and large, $d = 0.8 - 2.0$.

Null Hypotheses 1.1, 2.1, 3.1

H_0 1.1: The mean Full Scale IQ score for the ADHD-C group will not differ significantly from the mean FSIQ score for the Control group.

Hypotheses 2.1 and 3.1

H_0 2.1: The mean Nonverbal IQ score of the ADHD-C group will not differ significantly from the mean Nonverbal IQ of the Control group.

H_0 3.1: The mean Verbal IQ score of the ADHD-C group will not differ significantly from the mean Verbal IQ of the Control group.

The mean performance of the children and adolescents diagnosed with ADHD-C and the Control group on the Full Scale IQ, Verbal IQ, and Nonverbal IQ on the SB5 are presented in Table 4.6. The results of the MANOVAs and ANOVAs are also included in Table 4.6. The results presented in Table 4.6 indicate that the mean composite scores of the Control group are consistently, but

not significantly, higher as compared to the ADHD-C group. The SB5 score ranges are presented in Table 2 in the Appendix. The FSIQ scores for the ADHD-C group ranged from 75 to 115 whereas the FSIQ scores for the Control group ranged from 78 to 119. On the NVIQ scale, scores for the ADHD-C group ranged from 73 to 121, while the range for the Control group was from 69 to 125. On the VIQ scale, scores for the ADHD-C group ranged from 78 to 117 and the range for the VIQ score of the Control group was between 77 and 131.

Table 4.6

Means, Standard Deviations, F-values, and Effect Sizes (d) for Composite Scores for the ADHD-C Group (N=29) and Control Group (N=50)

	ADHD-C		Control			
Scale	M	SD	M	SD	*F*	*d*
FSIQ	97.59	8.93	99.18	10.80	0.45	0.16
NVIQ	96.72	10.63	98.02	12.56	0.22	0.11
VIQ	98.66	9.26	100.62	10.86	0.67	0.19

Note. FSIQ = Full Scale IQ; NVIQ = Nonverbal IQ; VIQ = Verbal IQ
d.f. = 77

One-way Analysis of Variance (ANOVA) was performed on the Full Scale IQ of the SB5. Levene's Test for Equality of Error Variances (i.e. tests that the error of variance of the dependent variables is equal across groups) indicated that homogeneity was met, $F(1,77) = 1.71, p = .195$. There was no significant

difference found between the performance of the ADHD-C and Control groups on the Full Scale IQ scores of the SB5. The effect size, calculated as Cohen's *d*, were found to be small. Using a .05 level of significance, there was a failure to reject null hypothesis 1.1.

Null Hypotheses 2.1 and *3.1* were tested simultaneously using the MANOVA procedure. Results are also presented in Table 4.6. Box's Test for Equality of Covariances indicated that the error of variance of the NVIQ and VIQs were equal across groups, F (3, 111041.9) = .47, p = .707. With the use of Hotelling's Trace criterion (τ), the combined dependent variables were not significantly affected by a diagnosis of ADHD-C with τ, F (2, 76) = .33, p = .72. The tests of between subject effects for the NVIQ and for the VIQ were not found to be significant. Levene's Test of Equality of variances indicated that the error variance of the dependent variables were equal across groups, with NVIQ with, F (1, 77) = 1.42, p = .24 and VIQ where F (1, 77) = .25, p = .62. Based on these results null hypothesis 2.1 and 3.1 are not rejected.

Null Hypotheses 4.1-4.5: The Factor Indexes

H_0 4.1: The Fluid Reasoning mean factor score of the ADHD-C group will not differ significantly from the Fluid Reasoning mean factor score of the Control group.

H_0 4.2: The Knowledge mean factor score of the ADHD-C group will not differ significantly from the Knowledge mean factor score of the control group.

H_0 4.3: The Quantitative Reasoning mean factor score of the ADHD-C group will not differ significantly from the Quantitative mean factor score of the Control group.

H_0 4.4: The Visual Spatial Processing mean factor score of the ADHD-C group will not differ significantly from the Visual Spatial Processing mean factor score of the Control group.

H_0 4.5: The Working Memory mean factor score of the ADHD-C group will not differ significantly from the Working Memory mean factor score of the Control group.

The means, standard deviations, F-values and effect sizes (*d*) of the Factor scale scores are presented in Table 4.7.

Table 4.7

Means, Standard Deviations, F-values and Effect sizes (d) of the Factor Scale Scores for the ADHD-C Group (N=29) and Control Group (N=50)

	ADHD-C		Controls			
Scale	M	SD	M	SD	*F*	*d*
FR	102.45	10.53	100.24	11.81	0.69	0.19
KN	92.79	11.37	97.68	13.84	2.59	0.38
QR	98.97	10.33	98.84	11.79	0.00	0.01
VS	101.07	11.00	101.76	13.12	0.06	0.05
WM	91.83	7.98	99.46	11.67	9.74*	0.76

Note. *d.f.* (1, 77); * Significant at <.05 level

The range of the Fluid Reasoning (FR) factor scores for the ADHD-C group was 76 to 123, whereas it ranged from 79 to 123 for the Control group. The Knowledge (KN) factor scores for the ADHD-C group were from 66 to 117, whereas the Control group's range for the KN factor scores was from 72 to 126. The Quantitative Reasoning (QR) factor scores for the ADHD-C group ranged from 81 to 116 and the QR factor scores for the Control group were between 72 and 119. The Visual Spatial Processing (VS) factor score range for the ADHD-C group was from 74 to 120 and the control group range on this factor was from 72 to 119. The last factor, Working Memory (WM) ranged from 77 to 109 for the ADHD-C group and 71 to 132 for the Control group.

Hypotheses 4.1 through 4.5 were tested simultaneously using the one-way MANOVA procedure. Box's Test for Equality of Covariances indicated that the error of variance of the Factor scores (FR, KN, QR, VS, and WM) were equal across groups where F (15, 13840.26) = 1.49, p = .099. With the use of Hotelling's Trace criterion, the combined dependent variables were significantly affected by a diagnosis of ADHD-C where τ, F (5, 73) = 3.78, p = .004. The subsequent analysis (Hummel & Sligo, 1971) indicated that four of the factors tested were nonsignificant: FR [F (1, 77) = .69, p =.41]; KN [F (1, 77) = 2.59, p =.11]; QR [F (1, 77) = .00, p = .96]; and VS [F (1, 77) = .06, p =.81]. The WM factor was found to be significant with F (1, 77) = 9.74, p = .00. The effect size of the between subject effects for the WM factor was 0.76, which is considered a medium effect size (Cohen, 1988). The power of the between subjects effects for

the WM factor was .86. Based on these results null hypothesis 4.1, 4.2, 4.3, and 4.4 are not rejected and hypothesis 4.5 is rejected.

Null Hypotheses 5.1-5.10: The Subtests

H_0 5.1: The Nonverbal Fluid Reasoning mean scaled subtest score of the ADHD-C group will not differ significantly from the Quantitative mean scaled subtest score of the Control group.

H_0 5.2: The Nonverbal Knowledge mean scaled subtest score of the ADHD-C group will not differ significantly from the Quantitative mean scaled subtest score of the Control group.

H_0 5.3: Nonverbal Quantitative Reasoning scaled subtest score of the ADHD-C group will not differ significantly from the Quantitative mean scaled subtest score of the Control group.

H_0 5.4: The Nonverbal Visual Spatial Processing mean scaled subtest score of the ADHD-C group will not differ significantly from the Nonverbal Visual Spatial Processing mean scaled subtest score of the Control group.

H_0 5.5: The Nonverbal Working Memory mean scaled subtest score of the ADHD-C group will not differ significantly from the Nonverbal Working Memory mean scaled subtest score of the Control group.

H_0 5.6: The Verbal Fluid Reasoning mean scaled subtest score of the ADHD-C group will not differ significantly from the Verbal Fluid Reasoning mean scaled subtest score of the Control group.

H_0 5.7: The Verbal Knowledge mean scaled subtest score of the ADHD-C group will not differ significantly from the Verbal Knowledge mean scaled subtest score of the Control group.

H_0 5.8: Verbal Quantitative Reasoning scaled subtest score of the ADHD-C group will not differ significantly from the Verbal Quantitative mean scaled subtest score of the Control group.

H_0 5.9: The Verbal Visual Spatial Processing mean scaled subtest score of the ADHD-C group will not differ significantly from the Verbal Visual Spatial Processing mean scaled subtest score of the Control group.

H_0 5.10: The Verbal Working Memory mean scaled subtest score of the ADHD-C group will not differ significantly from the Verbal Working mean scaled subtest score of the Control group.

The mean scales subtest scores, standard deviations, F-values, and effect sizes (*d)* are presented for the Nonverbal and Verbal subtests in Table 4.8.

Table 4.8

Means, Standard Deviations, F-values, and Effect sizes (d) for the Nonverbal and Verbal Subtest Scaled Scores of the SB5 for the ADHD-C Group (N=29) and Control Group (N=50)

	ADHD-C		Control			
Scale	M	SD	M	SD	*F*	*d*
Nonverbal						
FR	10.31	2.71	9.20	2.94	2.77	0.38
KN	8.62	2.64	9.34	3.05	1.13	0.24
QR	9.93	2.55	10.08	2.34	0.70	0.06
VS	10.34	1.97	10.28	2.93	0.92	0.02
WM	7.03	2.57	9.62	2.72	17.28*	0.95
Verbal						
FR	10.69	1.97	10.88	2.41	0.13	0.09
KN	8.86	2.28	9.90	2.87	2.77	0.40
QR	9.76	1.75	9.50	2.66	0.22	0.11
VS	10.07	2.52	10.34	2.60	0.20	0.11
WM	9.59	2.51	10.16	2.43	0.99	0.23

Note. *d.f.* (1, 77); * Significant at <.05 level

Table 4.8 provides the means, standard deviations, *F*-values, and effect sizes of the Nonverbal and Verbal subtest scores for the ADHD-C and Control

groups. The mean Nonverbal subtest scores for the ADHD-C group were higher, though not significantly, on the Fluid Reasoning and Visual Spatial Processing subtests as compared to the Control group. The ADHD-C group received lower, though not significantly, nonverbal subtest mean scaled scores on the Knowledge and Quantitative Reasoning. The largest difference between means was on the Nonverbal Working Memory subtest and was 2.59 points higher for the Control group, which was significant.

The mean Verbal scaled scores were higher, though not significantly, for the ADHD-C group on the Quantitative Reasoning subtest when compared to the Control group. The ADHD-C group received lower, though not significantly, mean scaled subtest scores on Fluid reasoning, Knowledge, Visual Spatial Processing, and Working Memory when compared to the Control group. This data is presented in Figure form in the Appendix as Figures 1 and 2.

Hypotheses 5.1 through 5.10 were tested simultaneously using the one-way MANOVA procedure with the alpha level set at .05. Box's Test for Equality of Covariances indicated that the error of variance of the ten scaled subtests scores was equal across groups where F (55, 11354.68) = .92, p= .635. With the use of Hotelling's Trace criterion the combined dependent variables were significantly affected by a diagnosis of ADHD-C with τ, F (10, 68) = 3.19, p = .00. The second stage of analysis (Hummel & Sligo, 1971) indicated that nine of the ten subtests tested were nonsignificant but the Nonverbal Working Memory scaled subtest score was found to be significant. When a separate one-way MANOVA was run for the five Nonverbal subtests it was found that the

combined Nonverbal subtests, using Hotelling's trace criterion, were significantly affected by a diagnosis of ADHD-C where F (1, 77) = 5.46, p = .00. A separate one-way MANOVA was also run for the Verbal subtests and the result using the Hotelling's Trace criterion was non-significant where τ, F (1, 77) = 0.73, p = .60.

Null hypotheses 5.1, 5.2, 5.3, and 5.4 are not rejected. Null hypothesis 5.5 is rejected. The effect size for the Nonverbal Working Memory subtest is considered to be large in this case (d = .95). For the Verbal subtests Null hypotheses 5.6, 5.7, 5.8, 5.9, and 5.10 are not rejected.

Results of Discriminant Function Analysis

Discriminant function analysis was performed on the ten subtests in order to assess if group membership to the ADHD-C or Control group could be predicted accurately. For the prediction to be robust, an assumption of concern – the homogeneity of the variance-covariance matrix – was not violated in this case (Box's M = .694, p = .584). The results of discriminant function analysis indicated that two variables were used in this stepwise analysis. The discriminant function is accounted for by Nonverbal Working Memory, [F (1, 77) = 17.28, p < .05]. The standardized canonical discriminant coefficient was 1.01. The Nonverbal Fluid Reasoning [F (2, 76) = 13.89, p < .05]. The standardized canonical discriminant function coefficient is -0.66. The classification statistics are presented in Table 4.9.

Only the Working Memory factor was capable of discriminating the two groups effectively. Adding any other factor into the analysis did not improve classification.

Table 4.9

Classification of Children as ADHD-C or Controls, Derived From Discriminant Function Analysis

	Predicted Group Membership	
Actual Group	Control (n = 50)	ADHD-C (n = 29)
Control	45 (90.0 %)	5 (10.0 %)
ADHD-C	9 (31.0 %)	20 (69.0 %)

Percentage of original grouped cases correctly classified: 82.3%

As indicated by Table 4.9, employing stepwise discriminate function analysis with the study samples, the percentage of original grouped cases correctly classified was 82.3%. The percent of children in the ADHD-C group that received a mean subtest scales score of one standard deviation or more below the mean (mean =10, standard deviation $\pm$ 3) on Nonverbal Working Memory was 62.1% (versus 22% in the Control group). The percent of children in the ADHD-C group that received a mean subtest scale score of one standard deviation below

the mean on the Verbal Working Memory subtest was 24.1% (versus 10% in the Control group).

Broad Summary of Results

The results of the testing of the presented statistical hypotheses of this study indicate that children with ADHD-C and children who were Controls do not differ significantly when comparing the Full Scale IQ, Nonverbal IQ, or Verbal IQ. When examining the five factor indexes that are generated from the results of the Stanford-Binet, Fifth Edition, these two groups do differ significantly on one factor, the Working Memory factor. Further examination at the subtest level indicates that it is the Nonverbal Working Memory subtest that differentiates the children with ADHD-C from the children that were classified as Controls. The children with ADHD-C displayed significantly lower performance on the Nonverbal Working Memory subtest scores when compared to their peers in the Control group. With the use of stepwise discriminant function analysis, these results were confirmed and it was found that the two groups could be differentiated from each other with 82.3% accuracy.

CHAPTER FIVE

DISCUSSION

The psychopathology of attention deficit hyperactivity disorder (ADHD), consisting of the behavioural symptoms of inattention, hyperactivity, and impulsiveness, is well recognized in children and adolescents, and is reported as one of the most frequently seen problems in child psychology and psychiatry (Taylor, 1998). There is significant heterogeneity among individuals presenting with the behavioural problems associated with this condition. Both clinicians and researchers have evolved different conceptualizations of the essential features associated with such behaviour resulting in different diagnostic traditions (Ostrander et al., 1998). Heterogeneity between individuals and diagnostic classification systems contributes to much of the conflicting evidence over the cognitive function or dysfunction in individuals with ADHD.

Intelligence tests provide a very broad index of higher cortical functioning and have predicitive validity for school achievement and diagnostic utility for clinical populations such as children with learning disorders (Kaufman, 1999). Although there has been concern about the utility of IQ tests in helping diagnose ADHD (Barkley, 1995), the psychometric properties of intelligence tests provide useful clinical information for the clinical group of children with ADHD (Tannock, 1998b). The development and release of the newest edition of the Stanford Binet Intelligence Scale, Fifth Edition (SB5), which was designed based on contemporary theories of intelligence, presented an opportunity to examine the

nature of intellectual functioning, via examination of profile patterns, in special populations.

Profile analysis of intelligence test scores aims to describe the child's unique ability pattern and goes beyond the information contained by a single Full Scale IQ score. The specific purpose of this investigation was to determine if there were consistent, observable profile patterns in the IQ, factor, or subtest scores of the SB5 for a group of children with ADHD-Combined subtype when compared to a Control group who had no significant behavioural or cognitive issues. The study was exploratory in nature and was intended to provide further information about the cognitive patterns that may be unique to these individuals.

The design of this study was practical in nature and attempted to attend to many of the methodological shortcomings of prior research. For example, many studies that have examined the performance of children with ADHD on intelligence measures have failed to take into consideration diagnostic subtypes, comorbid conditions, or use adequate control groups. This study used clearly defined criteria when establishing the experimental and control groups. Specifically, the children included in the experimental group were diagnosed with ADHD of the combined subtype and had no other potentially confounding conditions. The Control group was also selected based on stringent criteria.

This study is unique in that it examined profile analysis using the most recent version of a well recognized single measure of intellectual functioning, the Stanford-Binet, Fifth Edition (SB5). To date, there are no published studies on the diagnostic utility of this instrument, except for the one presented in the

Technical Manual of the SB5 (Roid, 2003b, c). Interestingly, in the competitive market of psychological test development, this tool is promoted as useful in its ability to identify populations with exceptionalities within the context of a psycho-educational test battery.

The ultimate goal of this study was to provide a detailed analysis of how children with ADHD-Combined[1] subtype perform on the SB5 Full Scale, Nonverbal, and Verbal IQ scales; Fluid, Knowledge, Quantitative, Visual-Spatial Processing, and Working Memory factors; and specific subtests when compared to the Controls. Understanding the cognitive capacities of children with ADHD-C, as measured by this major commercial instrument improves the clinician's understanding of the nature of the disorder as well as the nature of the tool itself.

This chapter summarizes the results of the present study and the questions and hypotheses proposed in chapters one and two are addressed. Identification of the limitations and delimitations of this study are presented as they affect the interpretation of the results. The implications for theoretical and clinical use are discussed and suggestions for further research are proposed based on the results of this investigation.

Current Findings and Original Hypotheses

This section compares the findings generated by this study to the original hypotheses generated in Chapter Three. The specific hypotheses about the

[1] ADHD-Combine subtype will herein be referred to as ADHD-C for the purposes of this discussion unless otherwise noted.

proposed performance of children with ADHD-C subtype on intelligence measures were generated based on the literature gathered in Chapter Two.

Hypothesis 1: The first hypothesis postulated that the mean Full Scale IQ score for the ADHD-C group would not differ significantly from the mean FSIQ score for the Control group. This hypothesis is supported by the findings of this study. There was no evidence that the Full Scale IQ scores differed significantly when comparing the ADHD-C and control groups. These data are consistent with previous studies that have employed the WISC-III and have found that the estimated Full scale IQs of children with ADHD did not differ significantly from a normal distribution (Fiorello et al., 2002; Kaplan, 2000; Tannock, 1998b).

Hypothesis 2: The second hypothesis stated that the mean Verbal IQ score of the ADHD-C group would be significantly lower than the mean Verbal IQ of the Control group. This postulation was based on prior evidence provided by research, such as Barkley (1998, 2000), which indicated that children with ADHD do more poorly on verbal subtests (from the WISC-III).

The results of this study, using the SB5, did not find statistically significant differences between the performance of children with ADHD-C and the Control group on the measures of verbal ability. These results do not support prior WISC-III research that has focused on verbal abilities. There may be several reasons for these findings. A number of studies that have indicated that children with ADHD score lower on verbal subtests, especially those that

contribute to the Verbal Comprehension Index of the WISC-R or WISC-III verbal subtests are thought to load heavily on working memory (Anastopoulos et al., 1994; Fiorello et al., 2002; Prifitera & Dersch, 1993; Schwean et al., 1993) which may be confounding the results of the studies. The construct of "Verbal IQ" of the WISC-III may not be as pure as it is for the SB5. The SB5 Verbal subtests were designed to not load as heavily on the WM factor.

A second reason for the differing results may be that many of the studies looking at the WISC-III Verbal IQs of children with ADHD had loose criteria for participant inclusion, often failing to differentiate between the ADHD subtypes which may have affected the results and conclusions made. Additionally, many of these studies worked with children with comorbid conditions that may have accounted, to some degree, for the results found.

Korkman and Pesonen (1994) used measures other than the WISC-III to evaluate the verbal abilities of children with ADHD. They compared 8-year-old children with pure ADHD (Combined subtype), specific learning disorder (LD), and both (ADHD + LD) on a comprehensive set of neuropsychological measures derived from the Neuropsychological Assessment of Children. The children with ADHD were specifically impaired in the control and inhibition of impulses; the children with LD were impaired in phonological awareness, verbal memory span, and storytelling, as well as in verbal IQ. Children with both showed all of these deficiencies; they also had more pervasive attention problems and more visual-motor problems than the two other groups. This study suggests that when comorbid learning conditions are accounted for, children with ADHD do not

differ significantly from non-ADHD children on verbal ability measures. However, they did not have a Control group without any disabling condition, so these conclusions are limited. These are consistent with the results of this study, which made a special effort to control for possible interfering learning conditions.

Hypothesis 3: The third hypothesis stated that the mean Nonverbal IQ score of the ADHD-C group would not differ significantly from the mean Nonverbal IQ score of the Control group. The results of the present study support this hypothesis and are consistent with prior research (Fiorello et al., 2002; Reardon & Naglieri, 1992; and Schwean et al., 1993) which has indicated that nonverbal scores of children with ADHD are generally in the normal range.

Hypotheses 4.1-4.4: These Hypotheses stated that there would be no significant differences between the mean factor scores of children with ADHD-C and the children in the Control groups on the Fluid Reasoning, Knowledge, Quantitative reasoning, and Visual Spatial Processing Indexes of the SB5. These hypotheses were supported by the evidence provided by this study, which did not find any significant differences in performance between these two groups on the described factor index scores. These data support Roid's (2003c) analyses of SB5 performance comparing children with ADHD and the normative group data provided in the SB5 manual.

Hypothesis 4.5: This hypothesis stated that the mean Working Memory factor score of the ADHD-C group would be significantly lower than the mean Working Memory factor score of the Control group. This hypothesis was supported by the data in this study. Working memory deficits were further analyzed by looking at the nonverbal and verbal subtest scores. The nonverbal working memory of children with ADHD-C was found to be significantly lower than the Control group. The verbal working memory subtest scores of the ADHD-C group did not differ significantly from the Control group's performance on the verbal working memory subtests.

This study supports the findings of other studies that imply that working memory is impaired in children with ADHD (Berlin et al., 2003; Weyandt & Willis, 1994). Barkley's Behavioural Disinhibition Theory (1997b) states that children with ADHD are expected to manifest deficits in the executive function of working memory ability. While this study does support Barkley's model of ADHD it does not rule out other models of ADHD such as that of Denney and Rapport's (2000) Working Memory model of ADHD. Denney and Rapport (2000) suggest that working memory plays a critical role in the organization of behaviour and attention in the environment. Disruptions in the ability to process incoming stimuli, resulting in disorganized behaviour, inattention, and impulsivity are postulated to be due to deficits in working memory. Denney and Rapport identify working memory processes as a primary deficit, with other symptoms, such as disinhibition, are described as secondary deficits. Barkley (1997b) places working memory as a secondary impairment resulting from disinhibition. While

low working memory scores are hypothesized to manifest in children with ADHD, and these hypotheses were supported by the evidence gathered in this study, it was not possible to clarify the nature of these working memory deficits as primary or secondary impairments.

Baddeley (1986) further delineated the character of working memory deficits within his Working Memory model. Baddeley indicated that working memory deficits are most commonly observed in tasks which depend on simultaneous storage and processing, while simple storage and rehearsal tasks are relatively unimpaired (Karatekin, 2004; Roodendrys et al., 2001). When working memory was assessed deficits were found in both the verbal and nonverbal performance of ADHD children (Barnett et al., 2001; Karatekin, 2004; Roodendrys et al., 2001). Baddeley's model has been tested by others and this research has not found impairments in either the verbal or nonverbal performance of children with ADHD (Karatekin, 2004; McInnes et al., 2003; Roodendrys et al., 2001). However, the assessment measures employed in these studies involved measures of short-term memory but did not assess the central executive and its' subsidiary systems (Karetekin, 2004).

When considering ADHD within the framework of Baddeley's model, verbal and nonverbal working memory task performance is expected to differ for ADHD children when compared to controls. Application of his model to children with ADHD suggests that there will be low Working Memory scores on the verbal subtest tasks because of possible cognitive process deficits in an individual with ADHD's "verbal sketch-pad" of short-term memory. The results

of the present study are consistent with Baddeley's theory in that Working Memory differed significantly between the two groups tested, with the ADHD group doing more poorly on these tasks. However, the results of the present study are inconsistent with the hypotheses in that it was not verbal, but rather nonverbal working memory scores that were significantly lower in the ADHD-C group.

This study proposed that the working memory deficits found in ADHD-C children would be found in both the verbal and nonverbal subtests of this factor. Instead, scores on the nonverbal working memory factor were significantly lower than the scores on the verbal working memory factor (the Control group did not demonstrate deficits in working memory, either on the verbal or nonverbal subtests). The visuospatial sketchpad, also known as nonverbal working memory, is assumed by Baddeley (1994) to be a system for maintaining and manipulating visual and spatial information. Several functions of the visuospatial sketchpad have been proposed, including the hypothesis that it is involved in the processing of visual information, in planning and other executive tasks, in keeping track of the changes in the visual perceptual world over time, and in maintaining orientation in space and directing spatial movement (Kahneman, Treisman, & Gibbs, 1992; Thompson, 1983).

Grodzinsky and Diamond (1992) found that children with ADHD have lower performance than controls on tasks that measure visuospatial planning and nonverbal working memory (e.g. Porteus Mazes and Rey-Osterrieth Complex Figure). Other studies found that children with ADHD exhibited impaired performance on a variety of tasks, some of which are based on nonverbal memory

abilities (Douglas & Benezera, 1990; Sadeh, Ariel, & Inbar, 1996; Siedman et al., 1995, 1997). Additionally, children with ADHD have been found to perform significantly lower (compared to non-ADHD children) on the Visual Memory Index of the WISC-III, which is comprised of three subtests measuring visual immediate/working memory (Mealer, Morgan, & Luscomb, 1996). Conversely, children with ADHD did as well as children without ADHD on Vocabulary and Information subtests of the WISC-III, which require retrieval of verbally-based information from long-term storage. The authors concluded that children with ADHD have problems with nonverbal working memory but not verbally based short or long-term memory. This reasoning is supported by the evidence of this study.

Additional ways of explaining the differential performance on the verbal and nonverbal working memory subtests comes from more recent studies. Much of the early research examining Baddeley's phonological loop and visuospatial sketchpad has depended on measures that we now understand to load on short-term, rather than working memory (Karatekin, 2004). More recent studies have used instruments that are thought to measure the construct of working memory. While Barnett et al. (2001), Karatekin (2004), and Roodendrys et al. (2001), found verbal and nonverbal deficits manifested in the performance of children with ADHD, there are some possible alternative explanations to account for the working memory verbal-nonverbal differences found in the present study.

Recent studies have proposed the idea that the visuospatial sketchpad depends more strongly on a central executive than the phonological loop, thus

resulting in asymmetry in these working memory slave systems. (Baddeley, 2003; Baddeley & Logie, 1999; Vandierendock, Kemps, Fastame, & Szmalec, 2004). The central executive has been suggested to house the control of attention and action, to regulate information flow through the working memory system, and to operate the retrieval of information from long-term memory (Baddeley, 1999, 2002). Baddeley and Hitch (1974, 1994) hypothesized that the phonological loop and visuospatial sketchpad are slave systems which enable the central executive, which has a limited capacity, to offload some of its own capacity for performing more complex information processing tasks. The research presented by Vandierdock et al. (2004) found that if verbal and nonverbal abilities are controlled for and held constant, measures of nonverbal working memory may result in more impairments than verbal working memory when a higher load is placed on the central executive.

A meta-analysis which examined the working memory function of children with ADHD found that children with ADHD exhibit moderate to large impairments in WM, with the magnitude of the impairment varying according to the modality of the WM task (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005). Large impairments were evident in both the spatial storage and spatial central executive domains, whereas more modest deficits were found in verbal storage and verbal central executive domains.

It is possible that the nonverbal memory tasks of the SB5 load more highly on the central executive, which may account for poorer performance on the nonverbal subtest of the Working Memory factor (versus the verbal Working

Memory subtest of this factor) in children with ADHD-C. The present study's results suggest that the theory that there is asymmetry in the slave systems of the central executive when the central executive is under pressure has merit. However, it is unknown what aspects of the working memory factor subtests, verbal and nonverbal, place a higher load on the central executive. The concept of the "central executive" is highly complex and not yet well understood. Further research that explores the differences in the central executive subsidiary systems and their relationship to the central executive would enlighten our understanding of children and adults with deficits in working memory.

Limitations

This study depended on archival data. Therefore, these studies relied on several clinicians to accurately administer, score, and interpret the psychometric measures used. Utilization of archival data depends on retroactive group classification that increases the margin of error in terms of misclassification. The primary limitation in using a clinic-referred population is that it reduces the ability to generalize results to a non-clinic referred population. Selection bias can be problematic when studying these populations. Individuals were not randomly assigned to groups because each individual came to the clinic presenting a referral issue which ultimately guided the assessment battery administered. In an attempt to control this issue, inclusion as a participant depended on several criteria as defined by the operational definitions described in this chapter. In addition, the types of individuals that come to a teaching clinic

may not be precisely representative of the general population of individuals that receive psychoeducational assessment.

The large age-range of children utilized in this study is also a limitation in that it was not possible to create a smaller age range with enough participants for the purpose of statistical evaluation. Specific developmental changes that may have occurred over the course of childhood and may have had an impact on the cognition of the participants. This may be problematic when making generalizations about the nature of cognition in children with ADHD because it is recognized that differences may exist between children of variable ages especially when considering the history of treatment, educational experiences, and neuropsychological features of the individuals involved (Baddeley, 1986; Karaketin , 2004). This age range may limit reliability and validity but was selected to match the data that was available, restricted by the small sample size.

This study is also limited because it depended on a quasi-experimental research method in that the independent variable was not limited and participants were pre-assigned to the groups. This limits conclusions in terms of establishing causal differences. This study is also limited in terms of generalizability from the group level to the individual due to the idiosyncratic nature of the disorder as well as the infrequency of a singular diagnosis of ADHD without other conditions.

Delimitations

Generalizations are limited to the groups of students who met the specific research criteria delineated in this study. Use of a relatively homogeneous group

of children with ADHD-Combined type and no comorbid conditions in order to answer the questions outlined in this study was necessary so that the number of extraneous variables that could affect the data was controlled.

An additional threat to the validity of this study is the threat of instrumentation. Instrumentation refers to any element that would change the calibration of the test. The present study makes use of multiple examiners in gathering the data. However, ll examiners were trained through coursework in the standard administration of these instruments and testing procedures in general. Each assessment (including protocols, test results, and assessment reports) was further examined by qualified personnel, such as chartered psychologists or doctoral level psychology graduate students with substantial experience in testing. The data entered into the computer database was checked by an independent individual to ensure that translation errors were not made during scoring or item entry.

Implications of Finding and Directions for Future Research

Working Memory Factor

The Verbal and Nonverbal Working Memory tasks of the SB5 were adapted and modified from previous instruments with the intention increasing the validity of these indexes and limiting confounding factors such as reading skills and short-term memory that may reduce the validity (Roid, 2003c). Additionally, compared to other measures of cognitive ability, the SB5 may be a useful tool when assessing children with ADHD as the Working Memory tasks do not rely

heavily on other academic abilities, such as word recognition, reading comprehension, or mathematical skill. The validity of a test develops as research is accumulated, from the time of initial test development and standardization procedures to the period in which independent researchers evaluate specific aspects of the measure in question.

At the time of this study no other research addressing the validity of the working memory factor of the SB5 exists outside of test development. This study supports the validity of the Working Memory factor based on comparisons of performance of the ADHD-C group relative to the Controls. Because the ADHD children are hypothesized to have impaired working memory, and the results of this study confirm this, these results represent criterion-related evidence of validity. The results support and build on the results of the standardization process, which also found children with ADHD to have lower working memory scores (Roid, 2003c).

It is important to apply caution when examining the validity of the Working Memory factor as the SB5 does not clearly delineate working memory and short-term memory processes. While the test developers indicated that an effort was made to reduce the effect of short-term memory processes on the Working Memory factor (Roid, 2003c) there is insufficient evidence to support this declaration. While the low scores of the ADHD-C group on the Working Memory factor may reflect true working memory impairments, they may also reflect deficits in short-term memory processes. Based on the results of prior research it is believed that the memory deficits associated with ADHD are due to

problems with working memory rather than short-term memory (Karatekin, 2004; Roodendrys et al., 2001). To better further validate the Working Memory factor use of both specific working memory tasks and short-term memory tasks would need to be employed concurrently to ensure that these two processes are delineated.

The tasks of Working Memory factor of the SB5 are theoretically based on Baddeley's Working Memory model (1986). Based on this model it is proposed that working memory deficits are due to impairments in the central executive. The lower nonverbal Working Memory scores of the ADHD-C group provide some preliminary support for this theory; however, the Working Memory factor does not permit a detailed analysis of the separate subsidiary systems and central executive processes. While the Working Memory factor of the SB5 may represent a valuable instrument in the study of cognitive and academic impairments associated with ADHD-C, this factor is not appropriate for analyzing the specific nature of the working memory deficits associated with ADHD-C.

Using a dual-task paradigm (Baddeley, 1992; Gathercole, 1999), in which the ability to divide attention between the memory tasks is measured and the separate components of the working memory system can be analyzed. Tests could be developed and tested on specific populations with working memory deficits in order to clarify the nature of the central executive and subsidiary systems and investigate what stage or stages of processing comprise a processing bottleneck and investigate WM capacity limits (Karatekin, 2004). These tests would represent an important step in illuminating the nature of working memory

deficits in children and help us understand the influence of these specific deficits on other educational or cognitive abilities.

Psychoeducational Assessment of Children with ADHD

The high prevalence rates and long-term impact of ADHD is of great concern to psychologists, educators, children, and the families of those affected directly or peripherally. Accurate and reliable diagnosis is imperative if the best outcomes are to be achieved (Daley & Nagle, 1996). Psychological assessment is generally oriented towards three goals: determining if a problem exists, evaluating the scope and magnitude of a problem if one has been determined to exist, and providing information that is relevant to intervention or treatment of the identified problem.

Intelligence tests are frequently an integral part of the psychological assessment batteries that are conducted in school settings (Kamphaus, 1993). One function of these measures has been diagnostic in nature, centered on distinguishing children with exceptionalities from others in the general population (Roid, 2003c; Sattler, 1992; Wechsler, 1991b). It has been proposed that children with attention deficit hyperactivity disorder (ADHD) will show significant differences on tasks that demand increased degrees of sustained attention, working memory, mental computation, reasoning, problem solving, hindsight, forethought, and application of planning and organizational skills (Barkley, 1996, 1997; Siedman et al., 1997).

Many of these skills and abilities are thought to be associated, to at least some degree, with intelligent behaviour (Ackerman, 2005; Politano & Finch, 1996). While there is no singular measure that can make a precise diagnosis of ADHD, assessment tools that can quantify certain aspects of cognition associated with this disorder do exist. These tools can contribute to our overall understanding of how cognitive functioning in children with ADHD differs from that of other children without this disorder.

The current research supports the position that the Working Memory factor of the SB5 is an appropriate screening instrument for the working memory deficits hypothesized to be associated with ADHD (Tannock, 1998a). Similar working memory deficits for children with ADHD were found in the standardization sample, adding to the validity of this factor. Despite these findings, the SB5 profile pattern for children with ADHD-C may not be sufficiently unique or specific enough to have diagnostic utility in determining whether an individual has ADHD-C.

The present findings do not indicate that a low working memory score assures that a child meets the diagnostic criteria for ADHD-C. A child with a low Working Memory score may not have ADHD-C, while a child with an average Working Memory score cannot be ruled out from having ADHD-C. Working memory deficits may also exist in other conditions, such as in specific learning disabilities of math or reading (Roid, 2003c.) The link between working memory deficits, learning disabilities, and inattention is confirmed by the research of Hulme and Mackenzie (1992). Reid, Hresko, and Swanson (1996) have reported

that even though memory problems are observable in both ADHD and reading disabilities, various factor profiles may not reliably differentiate between these groups. These issues make differential diagnosis of these disorders using the SB5 especially difficult, given that the profiles generated in this study were primarily flat, with only a single differentiating factor.

The results of this study indicate that the profiles generated (specifically, the low working memory factor score) may not be used as a single diagnostic indicator of ADHD-C. While the verbal and nonverbal subtest scores provide support to the idea that children with ADHD-C have unique deficits in working memory, subtest sores are generally considered less reliable than composite scores (McDermott, Fantuzzo, & Glutting, 1990) and care should be taken when interpreting patterns of score differences among subtests.

This study does support the recommendation that the SB5 can be utilized in conjunction with other standardized tools, such as behavioural rating and neuropsychological measures; qualitative evaluations such as interviews with parents and teachers; as well as a medical assessment, to provide an overall clinical picture of an individual with ADHD (Kaufman, 1994; Prifitera & Saklofske, 1998). Taken together with these other diagnostic indicators, the SB5 provides meaningful information that contributes to the assessment process and may inform treatment considerations.

Treatment Considerations and Educational Issues

The purpose of the profile analysis approach is to identify clinical types and diagnostic patterns, or to establish relative strengths and weaknesses of the cognitive abilities proposed to be measured by the test (Roid, 2003; Shelton, 1998). The literature on intelligence is controversial concerning the use of profile analysis approaches (Stanton & Reynolds, 1999), but it has supporters (Kaufman & Litchenberger, 1999, 2000) and is used frequently in the real world context of school psychology (Konold et al., 1999; Pfieffer et al., 2000). This study finds that profile analysis can contribute to our understanding of the individual but cannot provide us with adequate information to apply a diagnostic label to that individual in the absence of other information.

There is no doubt that using a broad index of cortical functioning, such as the SB5, can contribute to our understanding of a child with ADHD's individual strengths and weaknesses; however, it does not necessarily capture all the deficits specific to ADHD. Use of neuropsychological tests, such as the Stroop Task, Trail-Making, and Wisconsin Card Sorting Test, which provide indices of a wide variety of cognitive functions that afford insights into specific brain and behaviour relationships (Nigg et al., 1999) may be more sensitive to the subtle deficits that interfere with the functioning of a child with ADHD. Previous research on the neuropsychological functioning of children with ADHD suggests that there are deficits specific to ADHD (Siedman et al., 1997; Nigg et al., 1998) with more recent convergence on the broad domain of executive functioning.

The construct of executive functions overlaps closely with theories of prefrontal cortical functions. There is clinical and empirical evidence identifying the role of this brain region in executive functioning (Barkley, 1997; Weyandt & Willis, 1994). It has been argued that deficits in executive functioning play a key role in the cognitive and behavioural deficits and symptomatology associated with ADHD (Tannock, 1998a). The SB5 Working Memory factor captures one component of executive function, but additional assessment and research, with more specific tools, will provide clarification with regards to the specific areas of weakness in children with ADHD and inform treatment plans.

Appreciating and understanding the working memory deficits associated with ADHD-C may have significant implications for school psychologists. Deficits in executive functioning processes, specifically working memory, in children with ADHD are recognized to play a central role in their cognitive, academic, and behavioural functioning (Barkley, 1998; Klingberg, Forssberg, & Westerberg, 2002). Incorporating working memory training in the treatment and education of these children may help reduce the impairments associated with ADHD by dealing with the underlying features of ADHD. Klingberg et al. (2002) reported that working memory training improves both the behavioural and academic functioning in children with ADHD. Future research focusing on working memory training may prove valuable in developing alternative treatment and educational strategies to help children with ADHD and those who work with and educate them.

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APPENDIX

Table 1

Score Ranges for Achievement Test Scores for the ADHD-C Group and Control Group

	ADHD-C	Control
Test	range	range
WIAT-II*		
Math	90-110	85-120
Reading	88-103	80-118
Spelling	91-107	93-111
WJ-III**		
Math	82-114	80-120
Reading	80-123	87-139
Spelling	86-120	80-138
WRAT-3***		
Math	80-113	80-122
Reading	80-118	81-138
Spelling	90-115	80-132

*ADHD-C N = 13, Controls N = 9, ** ADHD-C N = 7, Control N = 18, *** ADHD-C N = 9, Control N = 23

Table 2

Score Ranges for Composite and Factor Scale Scores for the ADHD-C Group (N=29) and Control Group (N=50)

	ADHD-C	Control
Scale	range	range
FSIQ	75-115	78-119
NVIQ	73-121	69-125
VIQ	78-117	77-131
FR	76-123	79-123
KN	66-117	72-126
QR	81-116	79-119
VS	74-120	72-119
WM	79-109	71-132

Figure 1

Mean Composite and Mean Factor Scores for the ADHD-C and Control Groups

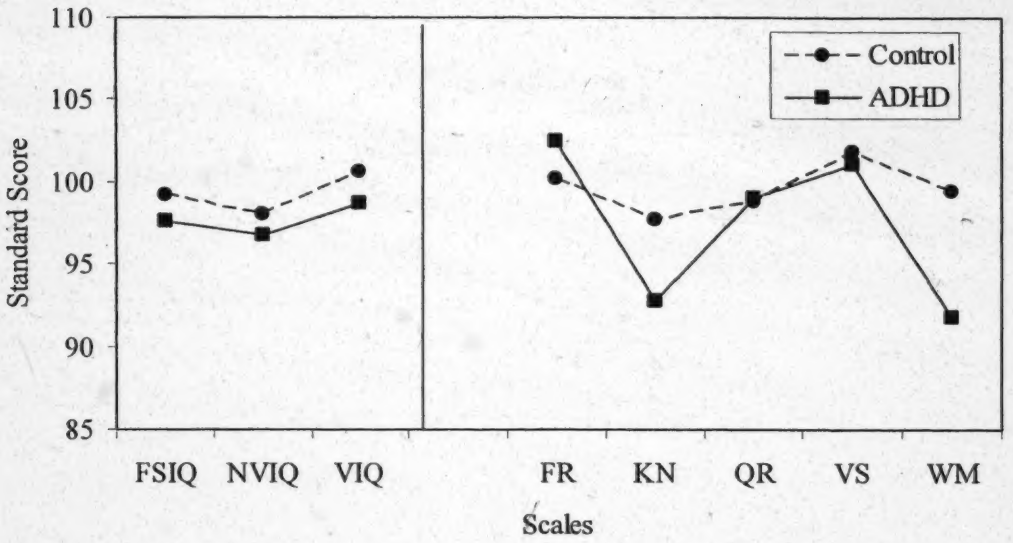
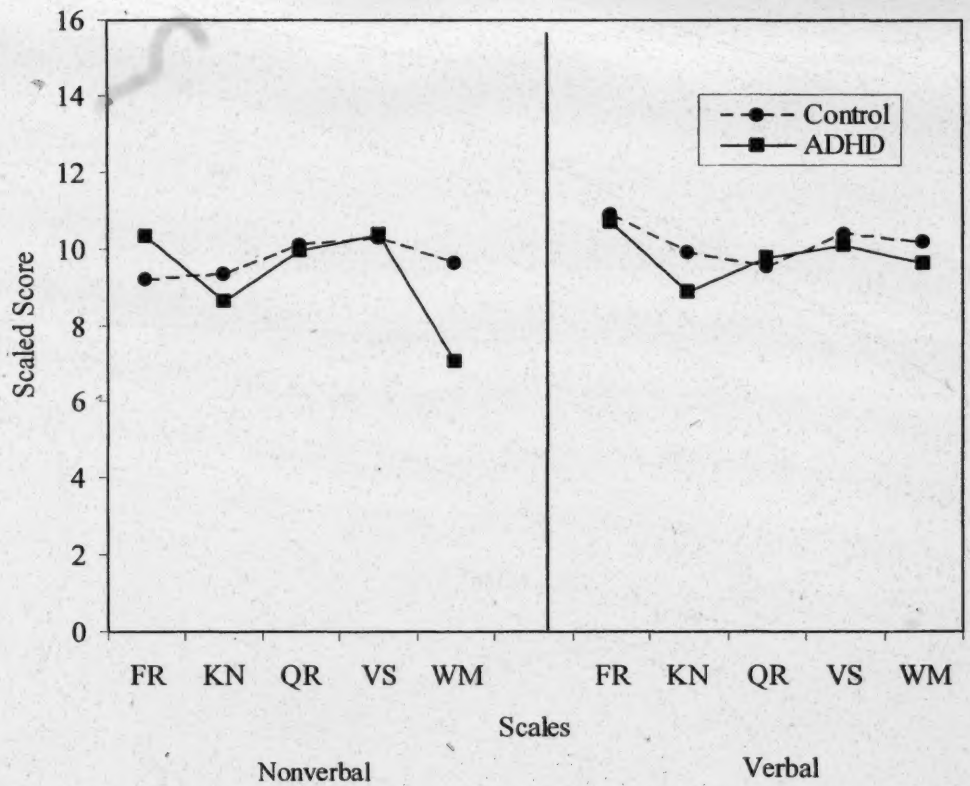


Figure 2

Mean Scaled Scores of the Nonverbal and Verbal Subtests